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THE HEREFORD EARTHQUAKE OF 1896.*

By CHARLES DAVISON, SC.D., F.G.S.

THOUGH slight earthquakes are not at all uncommon in this country it is fortunately but seldom that we are visited by a shock so strong and so destructive to property as that which occurred near Hereford on the morning of December 17th, 1896. The Essex earthquake of 1884 was productive of greater damage within a limited district, but the area disturbed by it is estimated at not more than fifty thousand square miles.

The accompanying map will show at a glance how much greater was the area affected by the Hereford earthquake. It includes the whole of England and Wales, with perhaps the exception of the three northern counties of Northumberland, Durham and Cumberland, and extending across the channel, entrenches upon the south-eastern counties of Ireland. The outermost continuous line (called the "isoseismal 4") bounds the region within which the shock was strong enough to make doors, windows, etc., rattle, but if the earthquake had not occurred at so early an hour (5.32 A.M.) there can be little doubt that it would have been perceived far beyond these limits. However, it was observed at the point of Ayre lighthouse (in the north of the Isle of Man), at Middlesborough, and at Flamborough Head lighthouse. Records have also come from more distant places, but, as these are somewhat isolated, it is not quite certain that they refer to the earthquake. The furthest from the bounding line just mentioned are Acklington, in Northumberland (fifty-nine miles distant), and Killeshandra, in County Cavan (sixty-five miles), and it is worthy of notice that the times at which the disturbances were observed at these places do not differ greatly from what they should have been, taking into account the velocity with which the earth-wave radiated from the origin.

It will be seen that the outermost line is very nearly circular in form, its dimensions being three hundred and fifty-six miles from north-west to south-east, and three hundred and fifty-seven miles from north-east to south-west. The area included within it is ninety-eight thousand square miles. If, however, the disturbed area were bounded by a concentric circle passing through Middlesborough, it would then contain one hundred and fifteen thousand square miles; and if by one through Killeshandra, as much as one hundred and eighty-five thousand square miles. Thus, the disturbed area can hardly have been less than one hundred thousand square miles—that is, it was at least twice as great as that affected by the Essex earthquake.

The continuous oval curves drawn upon the map represent *isoseismal lines* or lines of equal intensity of the shock; and are determined by reference to the Rossi-Forel scale of seismic intensity, an arbitrary scale in which the degree 1 corresponds to shocks so slight that they could only be felt by the most experienced observers, and the degree 10 to disastrous earthquakes by which whole towns and villages are overthrown. With the two highest degrees of this scale we have fortunately nothing to do in this country. The greatest intensity ever experienced by us, at any rate during the present century, is that numbered 8 in the scale, which refers to a shock capable of throwing down chimneys or cracking the walls of buildings. In the Hereford earthquake, damage of this kind occurred at no less than seventy-three places, fifty-five of which were in the county of Herefordshire. Marking these places on a map, and also those at which, so far as known, there was not the least damage done to buildings, and then drawing a line so as to include all the former and exclude the latter as far as possible, we obtain an isoseismal line corresponding to the degree 8 of the scale, a line which we may for brevity call the isoseismal 8.

Outside this line, no buildings were injured in any way, except in a few isolated cases. Thus, at Knightwick, two miles from the curve, stones fell from the top of a tall church spire, and, at three other more distant places, solitary chimneys were more or less damaged. The greatest destruction occurred in the city of Hereford and in some of the neighbouring villages. The cathedral escaped without very serious harm, but, in addition to some other slight injury, the three pinnacles at the west end were cracked near the top, and in each the upper detached portion was slightly displaced. The spire of St. Martin's Church was cracked right through about twelve feet from the top, and at Barr's Court railway station all the seven chimney-stacks were shattered. From inquiries made among builders in Hereford, Mr. H. Cecil Moore ascertained that certainly not less than two hundred and eighteen chimneys had to be repaired. At Dinedor, three miles south-east of Hereford, all the vicarage chimneys, eight in number, were knocked down and had to be rebuilt. And again at Fownhope, three miles further to the south-east, many chimneys were thrown down, and in falling caused much damage to the roofs of houses. These three

* Abstract of the writer's work on "The Hereford Earthquake of December 17th, 1896," published by Cornish Brothers, Birmingham.

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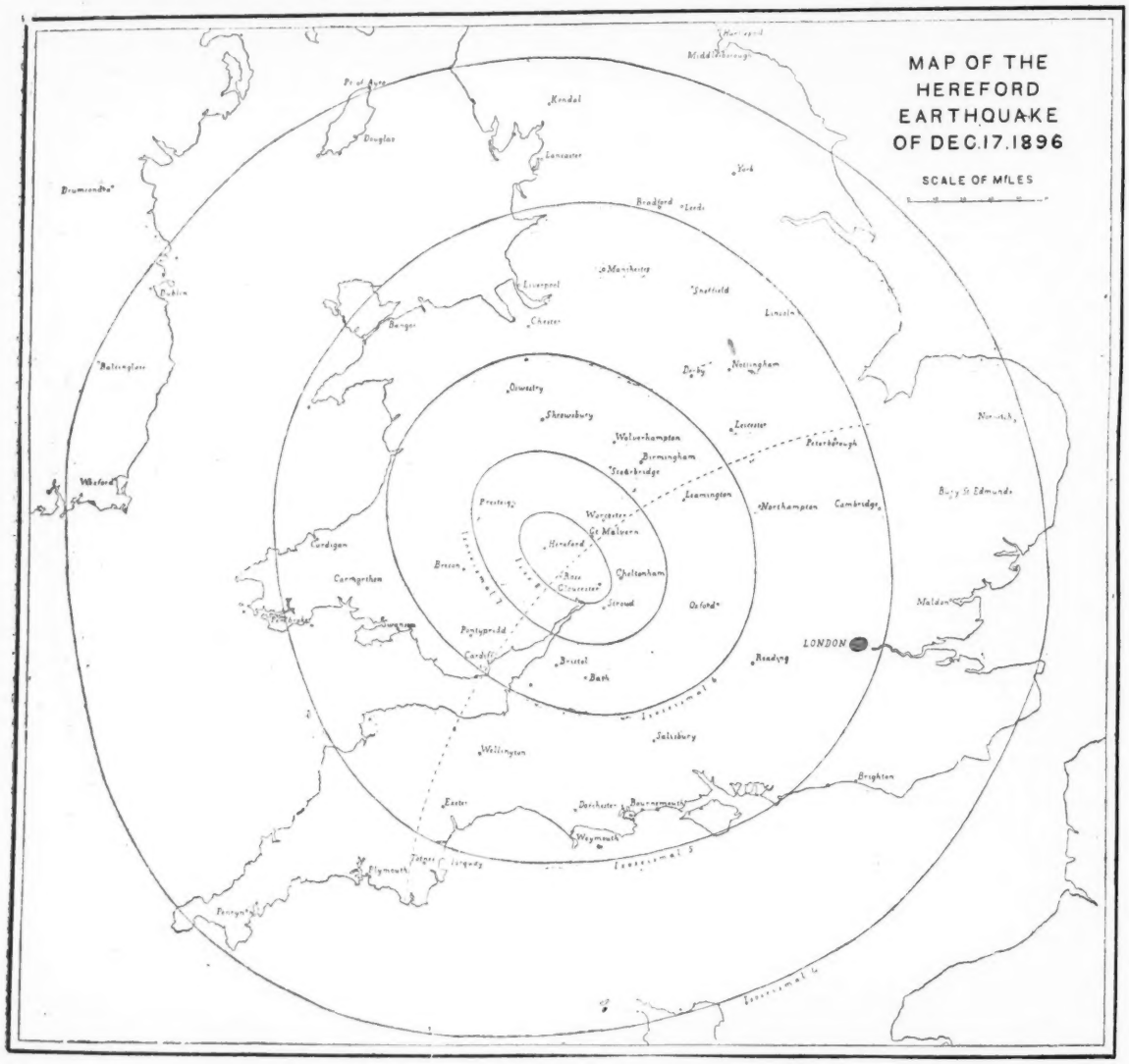
places seem to be those which suffered most severely from the earthquake.

The other isoseismal lines correspond to gradually lessening degrees of intensity. Within the isoseismal 7, the shock was strong enough to overthrow objects such as vases, picture-frames, etc.; the isoseismal 6 bounds places where chandeliers, pictures, etc., were observed to swing, and some difficulty was experienced in drawing this line, as so many observers seem to have slept in darkened rooms. Inside the isoseismal 5, the displacement of the ground was perceptible, and quite distinct from the quivering felt, say, in a railway station when a heavy train is passing. The isoseismal 4, as already mentioned, includes places where the shock was strong enough to make loose objects rattle, such as doors, windows, fireirons, etc. Large parts of the last two isoseismals traverse the sea, and in drawing them we have to be guided by the trend of the curves just before they leave the coast, and also by the known intensity at the nearest places on land. It is possible, of course, that their paths might have been found different had the sea been replaced by land, but as no deductions of any consequence depend upon them, except where they traverse land, the errors, if they exist, cannot be of great moment.

Returning to the isoseismal 8, we find it to be an oval curve, forty miles long and twenty-three miles broad, the longer axis being directed W. 44° N. and E. 44° S. It might be argued that the elongated form of the curve is due to the vibrations being more readily propagated along a north-west and south-east line than in the perpendicular direction. But, in 1863, another earthquake, almost as strong as that of 1896, originated in nearly the same district, and the area in which it was most strongly felt was also elongated, but along a north-east and south-west line. Thus, it appears that the form of these curves must be due to the focus being longer in one direction than in the other; and we may infer that, in the case of the Hereford earthquake of 1896, the longer axis of the focus was directed almost exactly north-west and south-east.

If the initial impulse were uniform all over the focus, the nature of the shock would be nearly the same through-



Map of Area affected by the Hereford Earthquake.

out the disturbed area. The chief variation would be in its duration, which would be greatest at places in the longer axis of the isoseismals, and least at those in the shorter axis. If the initial impulse were greatest at the north-west end of the focus, the shock would have been strongest towards the end at places to the south-east of the focus, and towards the beginning at places to the north-west. Now, this is what actually occurred—at least according to the majority of the observers who made notes on this point. As a rule, however, there was a break in the shock. In the south-east region, a series of rapid vibrations was first felt; then came an interval of two or three seconds, during which no motion was perceptible; and this was followed by a longer series of vibrations, stronger and slower than the first, and compared by many observers to the rolling of a boat when crossing the wake of a steamer, or to the oscillations of a carriage resting on good springs. Some persons at a distance from the centre describe the rocking as gentle and not unpleasant, but near the centre "the vibrations were so fierce and quick that they resembled the beats of an engine going at fifty miles an hour." In the north-west region the order of events was reversed, the first series being longer, more intense, and consisting of slower vibrations.

It is clear, from the variable nature of the double shock, that the focus cannot have been continuous throughout its length. The waves proceeding from a single focus cannot have been divided by reflexion or refraction at the bounding surfaces of different strata. Neither could the two series correspond to the longitudinal and transverse vibrations from one initial impulse, nor to successive impulses at the same focus. We must therefore conclude that there were two detached foci arranged along a north-west and south-east line.

An interesting question now arises as to whether the impulses at the two foci were simultaneous or successive. If they were simultaneous, then, at places along a straight line bisecting the line joining the two foci at right angles, the two series of vibrations would arrive together and only a single shock would be observed. Moreover, the boundary between the north-west and south-east regions in which the two parts of the shock were complementary would coincide with the same straight line. But this is not the case. The boundary is clearly a curved line concave towards the south-east, and the two series coalesce and form a single series at places within a hyperbolic band* which is traversed by the same boundary line. As the distance of any point on this band from the north-west focus is greater than its distance from the south-east focus, it follows that the north-west focus must have been in action a few seconds before the south-east focus.

Evidence leading to the same conclusion is afforded by the sound-phenomena of the earthquake. The deep rumbling sound which nearly always accompanies earthquakes was heard over about two-thirds of the disturbed area. It was most often compared to the noise made by heavy waggons, traction engines, or railway trains passing; sometimes to thunder, wind, the crash of a falling roof or other heavy bodies, or to explosions and the firing of heavy guns. The most marked feature of the sound was its extraordinary depth. It was, in fact, so deep, that it was inaudible to many observers. The records, however, show that persons differ widely in their powers of hearing deep sounds. To some it appeared very loud, like the rumbling of a traction engine heavily laden; while others, in the same places and equally on the alert, heard no sound at all. The audibility of the sound-vibrations must, of course, decrease with the increasing distance from the origin; but in the Hereford earthquake it did not depend only on the distance. For instance, in Herefordshire, the percentage of observers who heard the sound was eighty-seven, in Berkshire it was forty-four, while in the still more distant county of Lincoln it was sixty. If we consider the percentage in each county to correspond to the centre of the county, we can draw a series of curves of equal sound-audibility, which I have called *isacoustic lines;* the meaning of the line marked "60," say, being that sixty per cent. of the observers, within a small area having its centre on the curve, heard the earthquake sound. Now, these lines are irregular in form, and by no means concentric with the isoseismal lines. They are much elongated in two directions, one a little east of north-east, and the other a little south of south-west; and it is remarkable that a line drawn through the points of each curve which are furthest from the centre is concave towards the south-east, and coincides very nearly with the hyperbolic band along which the two series of vibrations were superposed. The explanation is evidently that at places along the line of greatest elongation of the curves the sound-vibrations from the two foci arrived simultaneously, and were audible to a larger number of observers*; and the concavity of this line to the south-east confirms the conclusion already arrived at with regard to the precedence in action of the north-west focus.

Most earthquakes which occur in non-volcanic districts appear to have their origin in the intermittent growth of faults. The mass of rock on one side of a fault slips, in extreme cases, through several feet; in most cases, perhaps, through a small fraction of an inch. But the area over which the slip takes place may be several miles in length, and the weight of the displaced rock-mass may be very great. The friction resulting from the sudden movement may thus be the source of the waves which, when they reach the surface, are known to us as an earthquake shock.

Now, since the surface of the fault is inclined to the horizon, the relative positions of the isoseismal lines will be different on the two sides of the fault, and ought, therefore, to throw some light on the direction in which the fault-surface "hades" or slopes. Referring to the map, it will be seen that the distance between the isoseismals is greater on the north-east than on the south-west side for the inner lines, and less for the outer ones. The inference from this is that the originating fault of the Hereford earthquake hades to the north-east. The fault-line must therefore be approximately parallel to the longer axis of the isoseismal 8, and lie a short distance to the south-west of this axis. Its exact position cannot be determined, but it probably passes through a point about one mile south-west of Hereford.

There is no fault on the Geological Survey map of the district to correspond with that suggested by the seismic evidence. But this is not surprising, for the area in which it lies is one covered by Old Red Sandstone, in which the detection of faults is difficult. A short distance to the south-east, however, there is a small triangular area of Silurian rocks, known as the May Hill anticlinal, the north-east side of which is bounded by a fault which, if produced, would coincide very nearly with the earthquake-fault. It should be noticed that the course of this fault, as traced on the Survey map, ends abruptly on the margin of the Old Red Sandstone, possibly on account of the difficulty of following it any further; and it appears to me

* The broken line on the map passes along the middle of the hyperbolic band.

* The same reasoning apparently leads to the conclusion that the isoseismal lines should have been distorted in a similar manner; but there was less inequality between the sound-vibrations from the two foci than between the larger vibrations which formed the true shock.

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therefore not unreasonable to conclude that the earthquake was due to a double slip along a continuation of this fault to the north-west.

Whether this be the case or no is not, perhaps, a matter of much importance. The noteworthy fact is that the earthquake-fault is roughly parallel to the axis of the well-known Woolhope anticlinal, and not far from its south-west boundary; that it probably forms part of the series of movements which have given rise to the structure of this interesting district.

It is not possible to determine the position of the two foci with very great accuracy, but, judging from the form of the isoseismal 8, the course of the hyperbolic band, and the duration of the two series of vibrations and of the interval between them, we cannot be far wrong in estimating the length of the north-west focus at about eight miles, with its centre beneath a point about three miles south-east of Hereford; and the length of the south-east focus at about six miles, with its centre beneath a point two or three miles north-east of Ross. Between the two foci there would thus be an undisturbed portion of the fault-service about two miles in length. With regard to the depth of the two foci, in this, as in every other earthquake, nothing definite can be stated.

One of the most interesting problems in connection with the earthquake is the origin of the double focus; and I venture to suggest the following as the solution. The earthquake fault, as we have seen, runs north-west and south-east. In the neighbourhood of the north-west focus, its hade is to the north-east. The hade may change to the south-west near the south-east focus and the May Hill anticlinal, but this is immaterial to the explanation. If we were to make a section of the north-east rock-mass by a north-west and south-east vertical plane, I imagine that beds originally horizontal would now be curved, so that there would be an anticline where the section passes through the Silurian Woolhope anticlinal, and a syncline through the newer rocks to the south-east, opposite the May Hill anticlinal. Between these folds there would be a region (corresponding to that between the two foci) where there is little or no vertical displacement. Now if the crust-movements which caused the earthquake were such as to accentuate this structure, there would be two slips—one at the north-west focus, that would be partly upwards and partly to the south-west (at least relatively to the rock-mass on the opposite side of the fault), and the other at the south-east focus, partly downwards and partly to the north-east, while in the region between them there would be no perceptible movement.

It should be mentioned, however, that there were several slight shocks—nine before and three after—the principal earthquake, and that three of these appear to have originated in the intermediate region. It is difficult, owing to the scarcity of observations, to locate the foci of some of the other shocks; but the majority of them seem to have been connected with the south-east focus. Possibly this is the reason why, in the principal earthquake, the vibrations from the north-west focus were so much more severe than those which proceeded from the other.

THE DISCOLORATION OF CUT APPLES.

By G. CLARKE NUTTALL, B.SC.

THE processes in the evolution of an apple tart present no difficulty to the most ordinary practical cook, though to the average learned scientist the gradual building up of this eminently English dish is apt to be a matter of some wonder. He wonders because he realizes his ignorance of culinary details and his helplessness if he be confronted with them practically; while, in her, familiarity has bred contempt to such an extent that she does not realize the limits of her knowledge, and can see no one thing in all the various details that calls for wonder or remark. And yet she might well do so, for at a certain stage that happens which has both puzzled and excited the interest of botanist and chemist, though she passes it by ignorant, and yet not knowing her ignorance.

As the apples lie piled up in slices in the dish waiting for their covering of paste, every housewife knows that they have a tendency to turn from their normal white to first a reddish, and then a brown colour, and that if they are left standing in the air uncovered for very long they become an unpleasant dirty-brown hue which is distinctly unappetising. So unappetising is the colour that if part of an apple be eaten and the rest put aside for a short time, a fastidious eater will throw it away rather than finish it, even though the flavour is quite unimpaired. This reddening of the flesh of apples cut and exposed to the air is one of those phenomena whose everyday occurrence has taken away curiosity, and ranged most people on the side of that cook who saw nothing in it to wonder at as "they always went like that!" And yet this change of colour is a Gordian knot which many have attempted in vain to untie, and which even yet is not altogether free.

Why should apples, pears, and, to a less extent, potatoes, thus change colour in the air, and only make this change when they are in their raw uncooked state? What is the true inwardness underlying this external symptom? To simply say it is due to a process of oxidation does not convey much definite knowledge to the inquirer, and, indeed, it is only during the past few years that much progress has been made in understanding better the reason of this change in colour.

The latest and most thorough explanation is one lately put forward by a chemist named Lindet, and it is an explanation of considerable interest. Within the cells of the tissues which make up the fleshy part of the apple—the part that is eaten—there is produced in their jelly-like contents a certain product to which the name malase or laccase has been variously given (malase will probably be the name finally used, as laccase has already been adopted for another product); and this product belongs to a curious class of substances known as enzymes. Enzymes have only been discussed seriously of late years, and even up to quite lately much doubt has been expressed as to what their properties are, and even indeed if they had any real existence or not; however, that point is now practically settled, and, in fact, they have been isolated and examined.

Now, an enzyme is a production of the activity of the cell which has the unique power of influencing other substances in its neighbourhood, and yet remaining unaltered in any way itself. It can exert influence without, apparently, being affected by doing so. Its own constitution is stable, but it possesses power to act, even at a distance, on certain of its surroundings, and produce great effects on the constitution of other matter, in some way not yet thoroughly comprehended. It will be seen at once that this is a very different thing from ordinary chemical action. In chemical action one substance acts on another by effecting some exchange, or producing some re-arrangement of the atoms comprising both substances. In combining with another it must itself be changed according to some definite law, and only through that change can chemical action be effected. Moreover, there is a definite limit to chemical action, and when once the new combination is brought about, and a stable equilibrium ensured, then there is an end of the matter until new substances come into play.

But with enzymes the case is very different. Apparently their power of influencing is illimitable. They do not change themselves and so they can continue to exert the influence that is peculiar to themselves for an indefinite time. There is no point of stable equilibrium in this relationship. Enzymes stand in a position of great interest nowadays when the search among the beginnings of life is so intense, and when the effort to prove or disprove spontaneous generation—the origin of life from the non-living—is so keenly maintained by chemists and biologists, for in one instance certainly where very careful and exact study has been made of an enzyme it is suggested that the substance stands midway between the organic and the inorganic, that it is the stepping stone across the gulf which has hitherto divided the great world of the living from that which has never known life.

Thus it appears that a simple consideration of the change of colour in a raw apple may lead back to the most far-reaching questions, and involve problems which touch closely the most incomprehensible matters of life and being.

The particular enzyme—malase—which is found in the cells of an apple effects its work by causing some of the oxygen of the air to be transferred from the air to a substance also found within the cells—the tannin—and it is suggested that it serves, in some sort of a way, as a carrier. And the result of its influence on tannin is that the nature of the tannin is altered, and dark-coloured substances, compounds of oxygen, are formed which dye the walls, first pinkish, then a dull red, and finally a dirty-brown. It is obvious that though the malase is probably always present in the cells, it cannot exert its influence to any purpose while the apple is whole, and surrounded by a firm clear skin, for the air cannot obtain admission until the peel is removed or the apple cut through, and hence there is no free oxygen to work with. But when the cells have been exposed the air enters, the malase transfers, in some mysterious way, the oxygen, the tannin is changed in nature, and the cells are dyed with the products. It is by no means certain that the malase and the tannin must be side by side in the same cells for this effect to take place. Lindet is inclined to think they are not, and that the malase exerts its influence for some distance, but this is a question which calls for further research before any more definite answer can be given.

The name oxydases has been suggested by Weigert for the enzymes which are engaged in the process of the transference of oxygen, a name which has the advantage of giving a clue to their function. This method of oxidation is quite distinct from the two other more familiar methods by which oxidation may be directly brought about: these two other ways being, first, the life processes in bacteria, where oxidation is an outcome of their vitality; and, secondly, the simple chemical fixation of oxygen, such as when sulphur dioxide (SO_2) becomes converted into the trioxide (SO_3) in the presence of oxygen.

But, as Prof. Lafar points out, the whole subject of oxydases, *i.e.*, of the oxidising enzymes, is yet in its infancy, but sufficient is known to give grounds for hope that it may prove to be a fruitful source of explanation in many instances where hitherto much has been perplexing, and that it may serve to throw light into dark places. The rapid discoloration of fresh vegetable juices is a case in point. These have always proved a source of difficulty to the botanist, and no really thorough comprehension of the subject has been arrived at, but now the recognition of these enzymes in plants is a help out of the maze. For now oxydases have been directly proved to exist in many fruits, such as pears, chestnuts, and quinces, and also in various vegetables, such as carrots, and potatoes, and beet, and the inner tissues of all these, as common experience shows, have a tendency to become discoloured when exposed to the air.

Malase and the other plant enzymes can be isolated by squeezing out the juice of the plant and mixing it with alcohol, when a precipitate is thrown down. This precipitate is then dissolved in water and filtered, and if again alcohol is added to the result a new precipitate will appear, which is the enzyme of the plant juice in question, and which is thus free for further examination and treatment.

It is not known as yet how many kinds of oxydases there are, but several of them are known to be the cause of familiar phenomena. For instance, it is only since 1895 that it has been effectively shown that the darkening of colour sometimes seen in white wines—the "browning of wines"—is due to the action of an enzyme which acts in the same way as malase in the apple, and its discovery has led to further knowledge as to the means of prevention of this trouble in viticulture.

Then, again, with regard to the darkening in colour of mushrooms and allied fungi when broken and exposed to the air, this was in 1895 found to be due to an oxydase which brought about oxidation in a similar way; and only quite recently in ripe olives another has been found which brings about spontaneous decomposition, but is not yet sufficiently studied to allow of much definite knowledge.

The laccase already mentioned earlier is an enzyme which plays the all-important part in the hardening and darkening of the plant juices which are the basis of the celebrated Japanese lacquer.

ON THE TREATMENT AND UTILIZATION OF ANTHROPOLOGICAL DATA.

By ARTHUR THOMSON, M.A., M.B.

III.—RACIAL PROPORTIONS.

MANY interesting facts relating to the various proportions of the body in different races may be culled from the vast number of measurements which have been made. Unfortunately, though the material at our disposal is very considerable, so varied have been the different methods employed by those responsible for the measurements that it becomes a matter of endless labour to form any generalisations from the statistics at hand. It has ever been the delight of the physical anthropologist to improve on the methods of his predecessor, and this improvement generally takes the form of some addition to the long list of measurements hitherto taken. In many cases these improvements are but an additional burden to the masses of figures already sufficiently numerous and perplexing. What is wanted, is not an increase, but a reduction in the number of the measurements deemed necessary.

It seems to us that the value of the different methods employed may be tested in a very simple way. Confining our remarks, for the time being, to the question of bodily proportions, it is only reasonable to suppose that the data supplied should be such as to enable a sculptor or modeller to apportion correctly the various members of the body. Subjected to such a test, most of the systems adopted by anthropologists break down miserably. Let anyone try it for himself. Taking the body height as equal one thousand, the various measurements of the limbs and trunk may be worked out in this proportion. If now an attempt is made to plot out on paper ruled in squares of centimetres the

proportions thus expressed, the experimenter will at once begin to realise the weakness of many of the systems of measurement. Taking the total height as one thousand, the length of the lower limb can be readily enough ascertained by deducting from this the sitting height. It is obvious, of course, that such measurement does not include the entire length of the femur, but for all practical purposes the length of the leg in the living may be expressed in this way. On looking up the various tables of measurements which the investigator may wish to compare, he will realise that some employ the method above described, whilst others measure the length of the limb from the perineum to the sole of the foot. As a matter of fact, these measurements may be regarded as practically the same. It is otherwise, however, when the length of the limb has been taken from the great trochanter, the pubis, or the anterior superior iliac spine, for then it is necessary to ascertain the exact position of these points in relation to the trunk; and here the difficulties begin. In regard to the length of the leg, using that term to mean the segment of the limb below the knee, we find that this is measured by some from the sole to the articular plane of the knee. In such cases it is easy to mark it off on the plan, but, unfortunately, others measure this distance from the lower border of the projection of the outer ankle instead of from the sole. This, no doubt, gives a more accurate measurement of the length of the bones of the leg as distinct from those of the foot, but, unfortunately, leaves us in a state of uncertainty as to the position of the knee, unless we know the distance of the summit of the malleolus from the ground; a measurement which in many of the tables given is omitted. But whilst, by a considerable amount of care and the exercise of much ingenuity, we may reduce the measurements of the lower limb to a common standard, we will find when we come to map out the proportions of the upper limb that the difficulties are much increased. No fault need be found with the methods recommended for the measurement of the various segments, but the experimenter with these figures will at once realise that there are insufficient data given to fix precisely the position of the summit of the limb. The point from which the entire length of the limb is usually measured is the tip of the acromion process. Now, it is only exceptionally that the height of this process from the ground is given; hence, although we may know the breadth of the trunk at this point (bi-acromial width), we have no means of assigning this width to its proper position in relation to the figure. It seems to us that this is a point of very considerable importance in discussing the proportionate lengths of the limbs; commonly we can readily distinguish the difference between long- and short- armed people by getting them to stand in the military position of attention and then note the level reached by the tip of the middle finger as it is applied to the side of the thigh. Thus Prof. Tylor, in his manual of anthropology, refers to the fact that "negro soldiers standing at drill bring the middle finger tip an inch or two nearer the knee than white men can do, and some have been even known to touch the knee pan." Now this is precisely what we wish to place on record, but so far as we know, the simple expedient of measuring the distance from the tip of the middle finger to the ground has never been adopted. We fear we are falling into the same error that we have discovered in others, but in suggesting such a measurement, we should be able to dispense with others which are of little use. The gain of such a measurement is obvious, for it would enable us to fix with certainty the position of the summit of the shoulder, for that would be easily ascertained by adding the total length of the upper limb to the measure of the distance of the tip of the middle finger from the ground. As the summit of the shoulder corresponds to the position of the acromion process of the blade-bone, it would at once enable us to assign the bi-acromial width to its proper position on the figure. That some such method is necessary must, we think, be admitted by anyone who has taken the trouble to endeavour to construct a figure from the data supplied. Furthermore, attention should be directed to the matter, for in the instructions provided for the measurement of the living, in the Notes and Queries on Anthropology, published by the Anthropological Institute for the use of travellers, there are no measurements suggested, either in what are termed the essential, the additional, or the special measurements, which would enable us either to determine the point on the thigh reached by the tip of the middle finger, or the height of the summit of the shoulder from the ground.

We fully agree with many of the suggestions therein contained. It is of great advantage to have the height of the sternal notch, and chin, from the ground, as these readily enable us to assign the correct proportions to the head and neck as distinct from the trunk. It may be that the measurement of the trunk, as determined by the distance between the perineum and the sternal notch, is not without objection, but, on the other hand, it is much more convenient than taking the length of the trunk from the seventh cervical spine to the perineum or tip of the coccyx, more especially because all the points of measurement may be viewed from the front of the body. We lay stress upon this fact, for it enables us to measure photographs of the nude figure and compare them with the data supplied by other observers. In taking these measurements, however, it cannot be too much insisted upon that the head must in the first instance be correctly adjusted with the axis of vision horizontal; or placed in such a position that the orifice of the ear and the lower orbital margin fall in the same horizontal plane; furthermore, once adjusted it should not be moved until most of the other measurements have been taken, for inattention to this rule leads to errors which oftentimes only attract attention when some such method of reconstruction as that suggested above is adopted. In our own experience in the work of some recent observers we have got results which were without doubt erroneous and misleading, and, no doubt, this was due to a change in the position of the head whilst some of the measurements were being taken.

For the purposes of proportion, apart from those especially relating to the head and face, the following measurements would in most instances suffice:—Total height, chin to sole of foot, sternal notch to sole, perineum* to sole, articular plane of knee to sole, distance from sole to tip of middle finger (assuming the person measured is in the military position of attention), total length of upper limb, length of cubit. If further measurements can conveniently be taken, then measure distance from sole to trochanter, this gives us the total length of lower limb, and we are now in a position to place the bi-acromial and bi-trochanteric widths in their proper positions. Were such data universally adopted it would be possible to map out the general proportions of the figure in graphic form. We do not in the least wish to prevent enthusiastic observers from taking what additional measurements they may consider advisable, but many of those universally adopted, such, for instance, as the span of the arms, are of little or no value.

The next difficulty we have to face is to know what to

* Or the height of the seated figure may be deducted from the total height in order to give the length of the lower limb, or the equivalent measurement,—the distance of the perineum from the sole.

do with all these figures when we have got them. For purposes of comparison between different races, it is essential that we should reduce them to a common standard, and this has been done by many anthropologists with much advantage and profit. The average proportions of different races may be thus numerically expressed, and by careful study and comparison of these figures, results of much value may be arrived at. But, as a matter of experience, we are bound to confess, elaborate tables of measurements convey little to our minds. We content ourselves, as a rule, with reading the summary, which the author may by chance have been good enough to supply; the tables are glanced at, to see if there is anything very striking about them, and then, unless our interest happens to be directed to some particular point, they are set aside, unstudied, and little appreciated. Now, there must be something wrong in all this. Considering the vast amount of time and trouble spent in securing these data, there should be some more profitable way of demonstrating the results than that usually adopted.

For statistical purposes curves have long been employed, and are extremely useful to express the variations which occur when dealing with one class of measurements (height, for instance), but when we have more than two factors to consider, curves become unmanageable, or, at least, so complicated as to be beyond the reach of all but expert mathematicians. In studying such a question as racial proportion, the reader will recognise that we have to deal with variations in the proportions of trunk to limbs, limbs to limbs, segments of limbs to each other, &c.; it is this complication in the inter-relation of the various parts which makes it so difficult to realise the true relation of each part to the other when expressed in figures. It seems to us that the only satisfactory method to adopt is to reduce the data to graphic form and so represent them. The advantage of such a system is that the eye is quick to pick out the characteristics of each type, and it is only necessary to run the eye along such a series of types to recognise what are the main features on which their differences depend.

In the diagram here given an attempt has been made to put these views into practice, with what success the reader must be left to judge.

As previously stated, the matter is not quite so easy as might be imagined, the difficulty being due to lack of uniformity in the measurements employed and the omission of certain measurements which are necessary to the scheme.

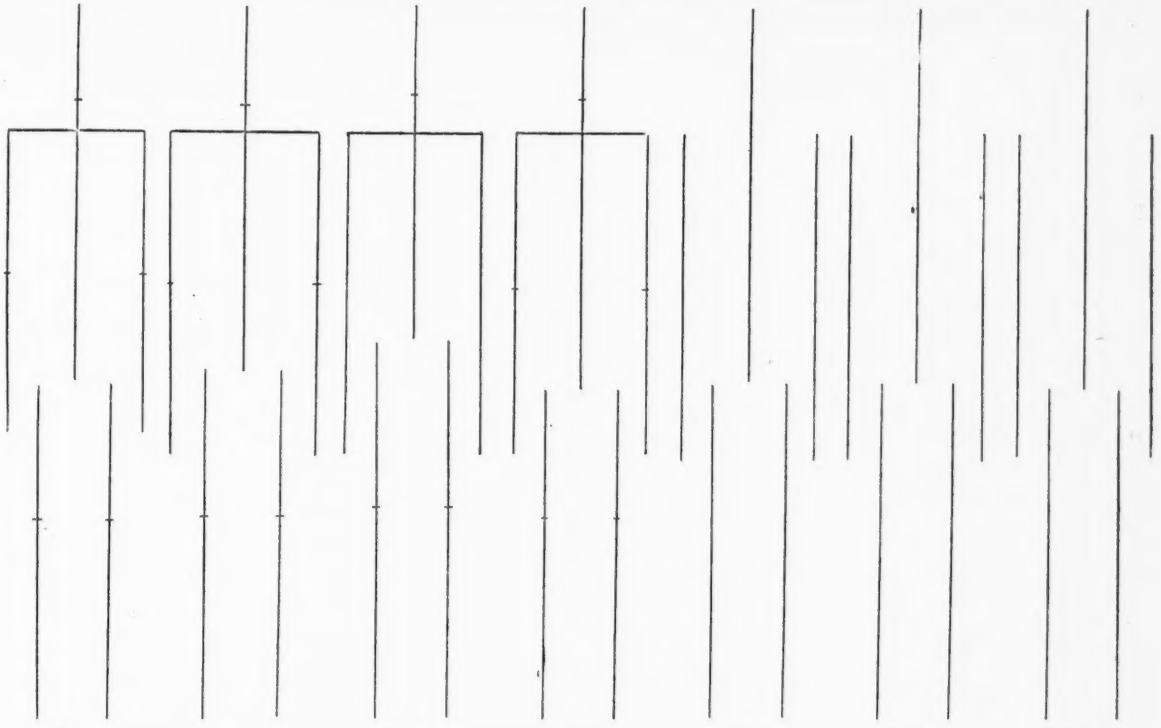

Fig. 1. 10,876 American Soldiers. Fig. 2. 2020 Negroes. Fig. 3. 20 Australians. Fig. 4. 517 Iroquois Indians. Fig. 5. 54 Javanese. Fig. 6. 40 Bataks. Fig. 7. 49 Southern Chinese.

Graphic Representation of the Proportions of some Races.

Each figure represents the proportion of the limbs, trunk and head in terms of one thousand. The first, second and fourth figures are constructed from data obtained from Topinard's work on Anthropology, the Australian type is based upon measurements given in Spencer and Gillens' "Tribes of Central Australia," whilst Figs. 5, 6, and 7 are derived from the data furnished by Dr. Hagen in his atlas of "Ostasiatischer and Melanesischer Völker" (1898). Apart from the racial characters which are here displayed in graphic form, the figures strikingly illustrate many of the points to which attention has been already directed. In no case have I been able to determine satisfactorily the point from which to draw the length of the upper limb (*i.e.*, the acromion process). In four cases I have assumed

that the acromion process lies on a level with the sternal notch, but this is a mere compromise, and as such unsatisfactory. Had we had the measurement from the tip of the middle finger to the ground it would have been easy enough to determine the position of the summit of the shoulder and the level of the bi-acromial width. For lack of satisfactory data the proportion of the head height is omitted in three, and for like reasons it has been impossible to determine the position of the knee, owing to the fact that whilst the length of the limb from the summit of the external malleolus to the articular plane of the knee has been given, the distance of the malleolus from the sole of the foot was omitted, and hence we were at a loss to determine the height of the knee from the ground. Yet, despite these deficiencies, most, we think, will admit that they will learn much more from a hurried comparison of the forms presented than from a prolonged and arduous study of the tables of measurements presented by the various authors. The long arms and the long legs of the negro are at once apparent, the shortness of the upper in contrast with the lower limb in the white man is very evident, whilst the short trunk, and proportionately longer lower limbs of the Australian are very strikingly displayed, The proportion of the upper limbs in the Javanese and Southern Chinamen is almost the same, but the shorter lower limbs of the latter are readily recognised.

It is along such lines as these that we venture to think progress will be made. Provided we can obtain the necessary measurements we can then present the results in a form which will demonstrate with greater clearness and more lasting effect those minor differences, on the sum of which racial distinctions depend.

SECRETS OF THE EARTH'S CRUST.

By GRENVILLE A. J. COLE, M.R.I.A., F.G.S., *Professor of Geology in the Royal College of Science for Ireland.*

III.—THE MAKERS OF FLINT.

THE association of flint with limestone, the former material so hard, taking the mark of steel, and the latter so soft and sectile, was observed by the ancients, and even led to some confusion in their nomenclature.* The contrast between the two rocks was striking; their relationship was certainly obscure. Long before limestone was used as a building-stone or for the production of lime, flints had been singled out for the weapons of primitive man. At a later date, the cavernous siliceous beds associated with certain limestones were used for millstones, and were exported from one land to another. When geology became a science, the mode of occurrence of these rocks required explanation; and difficulties were at once forthcoming. The grand curving bands of nodular flint, one beneath the other, on the headlands of the English Chalk, form a veritable feature of the landscape, and mark out the stratification of the series by their horizontal, folded, or even vertical lines. The less known flint-zones in the Portland beds of Dorsetshire play the same part on the pale limestone face, where it is shaped into cliffs against the sea. The darker colour of the Carboniferous Limestone, however, often masks the flint included in it; but in this rock also, throughout England and Ireland, siliceous bands are common. While there is a greater tendency to the formation of continuous beds rather than nodules, yet the Carboniferous flint often crosses from one layer of the limestone to another, and forms irregular lumps, quite in the Cretaceous style.

By custom, rather than any accurate definition, flint occurring outside the Cretaceous system has become styled "chert," the *hornstein* of the Germans. Some of these cherts are duller than ordinary flint, owing to a number of inclusions; but this is by no means the rule. Others, however, are merely sandstones cemented by chalcedonic silica, like the brown bands in the "greensands" of Leith Hill. But all kinds alike represent an alteration of the rock in which they occur—a feature that was not present on its deposition from the waters of the original sea or lake.

We must bear lakes in mind, for many flint-beds, crammed with fossils or casts of fossils, clearly originated in fresh water. The Oligocene "Calcaire de la Brie," well known in the wide plateau south of Paris, is often converted into a scoriaceous flinty deposit, which has long been found suitable for millstones. The fossils, *Limnæa*, *Planorbis*, and the spherical oogonia of *Chara*, give no clue to the cause of silicification, and are typical freshwater forms. Long ago, however, Cuvier and Brongniart* showed how the irregular hollows in such rocks resulted from the removal of limestone in solution; and they produced artificial millstone-rocks, or *meulières*, by treating siliceous limestones with nitric acid.

Macculloch,† about the same time, recognised the connection of chert and limestone, and regarded chert as a product of alteration. The views of D'Aubuisson des Voisins‡ were still more lucid, when he attributed the nodular masses of flint in the chalk to the coming together of silica, which was once uniformly diffused throughout the mass.

The origin of the silica, however, has given rise to many speculations. The boiling springs, or geysers, of the present day bring large quantities of silica to the surface in solution. Wherever, again, we find lavas rich in silica—notably the groups of the rhyolites and quartz-andesites—their hollows tend to become filled with opal, chalcedony, and agate; and most of the precious opals come from regions where volcanoes have been active in fairly recent times. Sometimes the entire rock becomes silicified; that is to say, its alkalies, alumina, lime, and magnesia, become removed, and silica insidiously replaces them, the structures of the original rock being still retained. Even basalts have thus been converted into jasper under the influence of percolating waters.§

Seeing that silica may be dissolved in spring-water through the presence of carbonates of the alkalies, it is natural to suggest that such water penetrates underground-masses, and deposits chalcedony in their interstices. This, indeed, seems the easiest way of making flint; and even irregular nodules can be explained as being formed along the more conspicuous water-ways of the rock-mass. Geologists of eminence, like M. Coquand,‖ have not hesitated to accept this view for ordinary flint.

Certainly, when we find "tabular flint," as it is appropriately called, filling up irregular fissures, or coating the planes of faults, we must admit that the material has been deposited there from solution; and the nodular flints occurring in the same rock-mass seem but another phase of the operation. But, even then, has the silica been derived

* *See* the wise remarks of Cæsalpinus, "De Metallicis" (1602), p. 84.

* "Description Géologique des Environs de Paris" (1822), p. 41.

† "Geological Classification of Rocks" (1821), pp. 565 and 570.

‡ "Traité de Géognosie" (1819), Tome I., p. 318.

§ C. Darwin, "Geographical Observations on Volcanic Islands" (1844), p. 46. A similar case occurs in Anglesey (*Sci. Proc. R. Dublin Soc.*, Vol. VII., p. 114).

‖ "Traité des Roches" (1857), p. 194.

from extraneous sources, or was it once, as D'Aubuisson said, uniformly diffused throughout the mass?

It is necessary to lay some stress on the infiltration theory, because it is so commonly true when applied to lavas, and may thus be true also of certain sedimentary rocks. The waters of modern geyser-regions frequently impregnate the trunks of trees before they have had time to decay under ordinary influences. Step by step, the organic matter passes away in combination with the alkalies of the solution, and the silica is deposited in its place. Here we have an example of the rapid silicification of non-volcanic material.

Yet we can hardly go as far as a recent writer, M. de Cossigny,* and argue, from the occurrence of true flint in fissures, that the nodular flints result from the filling up of cavities in the chalk. Many of these nodules are hollow, and so far remind one of the gradual choking of cavities in lavas, by the deposit of chalcedony on their walls. Such hollows, however, in the flints have long ago received another explanation; and their original contents, which are sometimes retained, have impressed observers as far back as the beginning of the century.

The fact is that, again and again, the fracture of a nodular flint discloses a fossil sponge. The hard parts, the spicular meshwork, of the sponge may be in very various conditions. Sometimes the general form is preserved, but the spicules are lost in a deposit of extraneous silica, which has bound the whole together into a white and knotty mass. Sometimes this mass crumbles between the fingers, sometimes it is almost as resisting as the nodule round it. In the latter case, dark flint will generally be seen filling its interstices, and the spicular structure is revealed in microscopic sections.

At other times, a pseudomorph or replacement of the sponge may occur in limonite, which is mere hydrated iron oxide, or iron rust. This probably results from the decay of a previous pseudomorph in marcasite, an iron sulphide which is highly susceptible to decay. Visitors to the south-east of England will notice how frequently, in the grey Lower Chalk, sponges have thus been replaced by brassy marcasite.

At other times, a mere powder remains in the hollow of the flint, and is found, on microscopic examination, to contain a few spicules, and silicified foraminiferal shells. Such powders offer a fertile field to the student of microzoa.†

Seeing that the enclosed sponges possessed, originally at any rate, siliceous skeletons, it seemed natural to conclude that additional silica had collected round them. Zirkel‡ quotes Parkinson, Guettard, de Luc, Faujas St. Fond, Dolomieu, and Huot, as early observers in this field. But the source of the additional silica still remained in doubt.

The association of flint and chert with sponge-remains became more and more evident as geological surveys spread. The grey flints of the Upper Greensand in the Isle of Wight are shot through, as it were, with minute rods, visible to the naked eye. Similar opaque rods abound in the brown cherts (cemented sands) of the Hythe Beds in the hills of Surrey. These are sponge-spicules in the form of casts, or even the hollows left by them; and their forms show that they also belonged to siliceous genera. The fact that these spicules are so often dissolved, like those of the sponges enclosed in nodular flints, is an important clue to the origin of the flint itself.

Similarly, Gümbel* reports that the siliceous limestones or marls of the Flysch system, in all the localities visited by him in the Alps, consist almost exclusively of sponge spicules. He does not comment on the actual condition of the spicules; but Dr. G. J. Hinde† has remarked that such bodies seldom remain in their original condition. Even when they still consist of silica, this is rarely the colloid form, easily soluble in hot solutions of caustic potash, but a replacement, in whole or in part, by chalcedonic silica. The axial canals of the spicules are, moreover, often filled by green glauconite, the curious silicate which accumulates from sea-water in so many recent deposits, and which colours our fossil "greensands" and glauconitic chalks. On complete solution of the spicule, the resisting cast of glauconite remains, often with the diverging rays that indicate, by their grouping, the division to which the original sponge belonged.

The ease with which the silica of sponge-spicules may go into solution is emphasised in the U. Jurassic beds of Bohemia and Würtemberg, where the sponges preserve their form, but have entirely, or almost entirely, decayed. Calcite has, however, crystallised in the hollows left by the removal of the spicular mesh, and the appearance is that of a complete calcareous sponge. Relics of the original silica may occur; but the character and arrangement of the spicules, and comparison with forms from other localities, serve more fully to convince the palæontologist that a thorough pseudomorphosis has occurred.

A few calcareous sponges, on the other hand, have locally been converted into siliceous pseudomorphs,‡ which adds to the complication. The microscopic study and collation of sponge-spicules has thus become essential, and geologists have reaped the results of the patient labours of the specialists.

In England, Prof. W. J. Sollas and Dr. G. J. Hinde have laid great stress upon the readiness of spicules to dissolve. The solution of such bodies may even be traced in the depths of existing seas. The ends of detached spicules become rounded, the axial canals become enlarged, and it is easy to note all stages of the process of destruction.

Hence the above-named authors have been foremost in urging that, not only did flint accumulate round siliceous sponges, but that the solution of the spicules of these and of other sponges provided the silica which thus accumulated. They see no need for mysterious springs and siliceous infiltrations, the occurrence of which, in association with beds containing sponge-remains, would be in itself a remarkable coincidence. The very absence of spicules from a rock, which otherwise appears to be an oceanic ooze—a rock, in fact, in which spicules should reasonably occur—and the presence of flint instead, is, for Prof. Sollas,§ clear evidence of the origin of the flint.

In 1878, Prof. Sollas‖ wrote: "In compact strata, such as chalk or limestone, it may be taken as an almost invariable rule that the replacement of organic silica by calcite is always accompanied by a subsequent deposition of the silica in some form or other; and thus, if one finds

* "L'origine des silex de la craie," *Bull. Soc. Géol. de France*, 3me. Sér., Tome IX. (1880), p. 47.

† *See* Jos. Wright, "Cretaceous Foraminifera of Keady Hill," *Proc. Belfast Nat. Field Club*, 1885-6, p. 328.

‡ "Lehrbuch der Petrographie," Second Edition, Bd. III., p. 552.

* "Aus den Alpen"; Letter in *Neues Jahrbuch für Min., &c.*, 1880, Bd. II., p. 287.

† "On Beds of Sponge-remains in the South of England," *Phil. Trans.*, 1885, Part. II., p. 427.

‡ Zittel, "Handbuch der Palæontologie," Bd. I.

§ On the Flint Nodules of the Trimmingham Chalk," *Ann. and Mag. Nat. Hist.*, Ser. 5, Vol. VI. (1880), p. 460.

‖ "On the Structure of the genus *Catagma*," *Ann. and Mag. Nat. Hist.*, Ser. 5, Vol. II., p. 361.

flints, chalcedonized shells, or minute quartz crystals in such strata, one will naturally look for the remains of the siliceous organisms which supplied them, and the search will seldom be unsuccessful."

The same author held that the absence of obvious deposits of silica indicated that the rock originally contained no siliceous fossils; but this point has recently been contested by M. Lucien Cayeux.

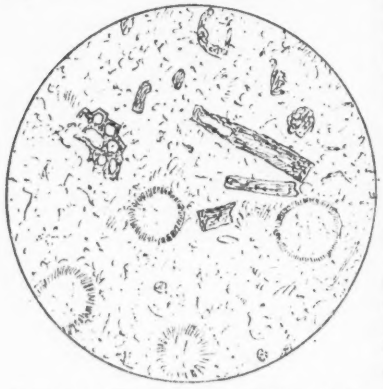

FIG. 1.—Microscopic section of Flint (silicified chalk) from gravel of Ardtun, Isle of Mull. × 100. Traces of sponge-spicules, represented by glauconitic casts of their axial canals; "ghosts" of foraminiferal shells, the interior being filled by clear chalcedony, and the perforations in the shell replaced by tiny rods of glauconite. The glauconitic change doubtless set in in the original chalk, and the siliceous replacement of the calcium carbonate followed.

Dr. G. J. Hinde's* work on the cherts of the Lower Cretaceous strata proved that the spicules of tetractinellid sponges supplied the silica that has cemented certain layers of the sandstones. Hence the abundance of these humble creatures at certain times on the floor of the Cretaceous seas has strengthened the Hythe Beds with sheets of silica, and has been, in all probability, responsible for their enduring qualities. Sponges have thus given us the Leith Hill scarp, the boldest feature in south-eastern England.

The fact that Mr. J. T. Young† found that even the freshwater flint of the Purbeck limestone contained spicules of *Spongilla*, a siliceous sponge, placed the sponges, as makers of flint, well in the ascendant. Dr. Hinde‡ showed later that the Carboniferous chert of Ireland gave rise, on its weathered surfaces, to a porous crust consisting of innumerable rod-like sponge-spicules, felted together in the plane of bedding of the rock. All his microscopic sections of these cherts exhibited spicules.

The wide-spread layers of tabular chert and flint, excluding those formed in joints, may be explained by Sollas's§ argument, that many sponges are known to extrude their spicules during life. These become spread out thickly on the sea-floor, and thus each individual sponge does much more in promoting the growth of flint than it could by merely depositing its final skeleton.

In the same paper, Prof. Sollas points out that diatoms and radiolarians must not be forgotten as makers of flint. The warning was, indeed, timely. Continental geologists, notably Dr. Rüst, had begun to describe the beautiful siliceous skeletons of radiolaria from Jurassic formations; and obscurer indications were known to occur even in the Trias. But most of this work dates only from 1879. The well-known Tertiary deposit of Barbados, which supplies the material for dealers in microscopic slides, is loose and incoherent, and has no apparent relationship to flint.

Similarly, the diatomaceous deposits of lakes—the "tripoli" and "kieselguhr" of commerce—were familiar as Tertiary materials, soft and powdery enough. In modern seas, also, especially in the Antarctic Ocean, siliceous oozes, formed of these humble plant-remains, were revealed by successive surveys.

Where, however, were the diatom-beds, freshwater or marine, of older periods? Why, moreover, were radiolaria, practically nowhere beside the host of calcareous fossil protozoa?

Dr. G. J. Hinde,* in 1890, described well preserved radiolaria from chert, occurring among Ordovician rocks in Lanarkshire and other counties in the south of Scotland. This was only the first of a series of papers, and "radiolarian cherts" at present hold the field of interest. Messrs. Hill and Jukes-Browne,† in describing calcite casts of radiolaria from the English chalk, have discussed the instability of the radiolarian skeleton. In fact, vast numbers of the more ancient radiolaria are for ever lost to us. Their remains have been, like those of so many sponges, dissolved and converted into flint.

Similarly, the still more delicate frustules of the diatoms have practically disappeared. Even those described by Mr. W. H. Shrubsole,‡ from the London clay of Sheppey, are converted into discs of iron pyrites. Yet how many flints, particularly those of freshwater formations, may in future be traceable to diatoms?

These three humble groups of organisms, two of them animal, one vegetable, may be regarded, then, as the essential makers of flint. They extract the silica from the sea-water, which derives it mainly in solution from the land; they deposit this as colloid silica in their skeletons; on their death, or, in the case of sponges, on the ejection of their spicules, the silica is slowly picked up again by the water, and ultimately comes out, in the consolidated rock, in the minutely crystalline form, chalcedony or flint. In this form it is proof against long attacks, though its white exterior, and sometimes its crumbling character throughout, show that some solution takes place, and that the unhappy organic skeletons are destined to no certain rest.

Dr. Hinde§ seems to have gone too far in asserting that the Carboniferous chert of Ireland was in no sense a pseudomorph of the limestone. Unless it has actually replaced the limestone, particle by particle, it is hard to account for the occasional ramifications of the chert-masses, and for the crossing of a mass from one bed of limestone to another. Prof. Sollas‖ properly insisted that flint may replace all the structures of ordinary chalk—as, indeed, section after section will assure the enquirer with the microscope. The foraminifera, coccoliths, and so forth, and, more rarely, the larger fossils, become completely replaced by the silica as it is redeposited. Similarly, the oolitic structure of some limestones becomes preserved in flint, and may even remain in this form when mineral changes have destroyed it in the actual limestone.¶ The whole position is clearly summarised by Prof. Judd;**

* "Catalogue of Fossil Sponges," British Museum (1883) p. 28.

† "On the Occurrence of a Freshwater Sponge in the Purbeck Limestone," *Geol. Mag.*, 1878, p. 220.

‡ "On the Organic Origin of the Chert in the Carboniferous Limestone Series," *Geol. Mag.*, 1887, p. 443.

§ "A Contribution to the History of Flints," *Sci. Proc. R. Dublin Soc.*, 1888, p. 4. *See* also *Ann. and Mag. Nat. Hist.*, Ser. 5, Vol. VI., p. 450.

* *Ann. and Mag. Nat. Hist.*, July, 1890, p. 40.

† "On the Occurrence of Radiolaria in Chalk," *Quart. Journ. Geol. Soc.*, Vol. LI. (1895), p 600.

‡ *Nature*, Vol. XXI. (1879), p. 132.

§ *Geol. Mag.*, 1887, p. 445.

‖ *Ann. and Mag. Nat. Hist.*, Ser. 5, Vol. VI. (1880), p. 447.

¶ *See* "Aids in Practical Geology," ed. 3, p. 204.

** "The Student's Lyell" (1896), p. 255.

and flints in limestone are as fully pseudomorphs as are the massive iron carbonates of Cleveland, or the silicified tree-stems forming at the present day.

Why some deposits contain flints and few traces of siliceous organisms, while others are rich in such organisms and contain no flints, is a question that has been raised, and which is still under discussion. The preservation of spicules may possibly, as Mr. Jukes-Browne* suggests, have been determined by the depth at which the bed was formed, solution going on under pressure in deep-sea deposits before the beds had actually consolidated. M. Lucien Cayeux,† however, leaves the matter very open. He concludes that "calcareous deposits of the same original chemical and organic composition give rise in course of time to three very different beds. The first preserves its silica disseminated throughout the rock; the second becomes an almost pure limestone with abundant flints; the third passes into the condition of a pure limestone without flints."

In the last case, as in the Upper Jurassic of the Mediterranean area, a rock may be full of casts of siliceous sponges and radiolaria, and yet the silica may be entirely withdrawn.

Has it not gone to form flint elsewhere? Even in this indirect fashion, the humble organisms, which are always the most potent, may still be the makers of flint in some other portion of the crust.

A NEW SATELLITE OF SATURN.

NEARLY all the astronomical discoveries made by the aid of photography have related to the fixed stars. In the study of the members of the solar system, the results obtained by the eye are generally better than those derived from a photograph. For many years it has been supposed that photography might be used for the discovery of new satellites, and in April, 1888, a careful study of the vicinity of the outer planets was made by Prof. William H. Pickering. Photographs were taken with the thirteen-inch Boyden telescope, with exposures of about one hour, and images were obtained of all the satellites of Saturn then known, except Mimas, whose light is obscured by that of its primary. It was then shown that Saturn probably had no satellite, as yet undiscovered, revolving in an orbit outside of that of Enceladus, unless it was more than a magnitude fainter than Hyperion. (Forty-third Report, p. 8.)

In planning the Bruce photographic telescope, a search for distant and faint satellites was regarded as an important part of its work, and, accordingly, plates for this purpose were taken at Arequipa, by Dr. Stewart. A careful examination of these plates has been made by Prof. William H. Pickering, and by superposing two of them, A 3228 and A 3233, taken August 16th and 18th, 1898, with exposures of 120^m, a faint object was found which appeared in different positions on the two plates. The same object is shown on two other plates, A 3227 and A 3230, taken August 16th and 17th, 1898, with exposures of 60^m and 122^m respectively. The position is nearly the same on the two plates taken August 16th, but on August 17th it followed this position 33″, and was south 19″, while on August 18th it followed 72″, south 43″. Its motion was direct, and less than that of Saturn, though nearly in the same direction. It cannot, therefore, be an asteroid, but must be either a satellite of Saturn or a more distant outside planet. The proximity of Saturn renders the first supposition much more probable. On August 17th, the position angle from Saturn was 106°, and the distance 1480″. Assuming that it was at elongation, and that its orbit is circular, its period would be four hundred days, or five times that of Iapetus. It was at first identified with a very faint object found on plates taken in 1897, and the period of seventeen months was derived from them. This supposition has not been confirmed.

Measurements of the positions of the images give additional material for determining the form of the orbit. The method of measurement is that described in the Annals, Vol. XXVI., p. 236. The uncorrected positions of the four images referred to the first plate of August 16th as an origin, are for x, 0·0″, +1·2″, +33·6″, and +71·8″; for y, 0·0″, −1·7″, −19·8″, and −42·1″; the corresponding Greenwich mean times are 12^h 16^m, 14^h 18^m, 12^h 56^m, and 13^h 12^m. Correcting for the motion of Saturn, the relative motion with reference to that body is in x, 0·0″, −2·4″, −10·7″, and −22·0″; in y, 0·0″, +0·1″, +2·4″, and +2·9″. It appears from this that the apparent motion is about 10·4″ a day, at a distance of 1480″. A computation shows that if the orbit is circular, the period must be either four thousand two hundred or four hundred and ninety days, according as the satellite is near conjunction or elongation. These values may be greatly altered if the orbit is elliptical. Since the interval of time between the first and last photographs on which the satellite appears is only two days, it is impossible to predict its position with accuracy. It is probable that its position angle from Saturn now lies between 280° and 290°, and its distance between 20′ and 30′. These uncertainties will probably be greatly diminished from measures of plates of Saturn taken in Arequipa on September 15th, 16th, and 17th, 1898, which for some unexplained reason have not yet been received in Cambridge.

The direction of the motion, which is nearly towards Saturn, shows that the apparent orbit is a very elongated ellipse, and that it lies nearly in the plane of the ecliptic. Prof. Asaph Hall has pointed out that this is to be expected in a body so distant from Saturn. The attraction of the latter only slightly exceeds that of the Sun. Hyperion appears as a conspicuous object on all four of the plates, and the new satellite appears about a magnitude and a-half fainter on each. The approximate magnitude is therefore about 15·5. As seen from Saturn, it would appear as a faint star of about the sixth magnitude. Assuming that its reflecting power is the same as that of Titan, its diameter would be about two hundred miles. It will, therefore, be noticed that while it is probably the faintest body yet found in the solar system, it is also the largest discovered since the inner satellites of Uranus in 1851. The last discovery of a satellite of Saturn was made in September, 1848, by Prof. William C. Bond, then Director of this Observatory, and his son, Prof. George P. Bond. The satellite Hyperion was seen by the son on September 16th and 18th, but its true character was first recognized on September 19th, when its position was measured by both father and son (*see* Annals, II., p. 12). Soon after, it was discovered independently by Lassell, at Liverpool.

Prof. William H. Pickering, as the discoverer, suggests that the name Phœbe, a sister of Saturn, be given to the new satellite. Three of the satellites, Tethys, Dione, and Rhea have already been named for Saturn's sisters, and two, Hyperion and Iapetus, for his brothers.

EDWARD C. PICKERING.

April 10th, 1899.

* "The Amount of disseminated Silica in Chalk, considered in relation to Flints," *Geol. Mag.*, 1893, p. 545.

† "Etude Micrographique des Terrains Sédimentaires," *Mém. de la Soc. Géol. du Nord*, Tome IV., 2 (1897), p. 443.

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NEBULOUS REGION ROUND THE CLUSTER N.G.C. NO. 2239 MONOCEROTIS.

By ISAAC ROBERTS, D.SC., F.R.S.

THE region to which the annexed photograph refers is comprised between R.A. 6h. 24m. 16s. and R.A. 6h. 29m. 13s., and in declination between 4° 24·8′ and 5° 56·5′ *north*. Scale—one millimetre to twenty-four seconds of arc.

Co-ordinates of the fiducial stars marked with dots for the epoch 1900.

Star (.) D.M. No. 1271 Zone +5° R.A. 6h. 25m. 30·7s. Dec. N. 5° 51·7′ Mag. 8·7
" (..) " 1288 " +4° " 6h. 25m. 44·7s. " 4° 35·2′ " 8·3
" (...) " 1302 " +5° " 6h. 28m. 49·4s. " 5° 12·5′ " 8·3

References to parts of this region have been made by Sir J. Herschel in the G. C. 1420, and by others in the N. G. C. 2237-38-39; also in the *Ast. Nach.*, No. 2918, pp. 253-4, *Astron. and Astro-Physics*, Vol. XIII., p. 178.

The photograph was taken with the twenty-inch reflector, and exposure of 2h. 45m., on 1899, March 5th, and presents the object to us in complete form, and with much detail, so that we may draw inferences, and also pass on to future astronomers' records, of a reliable character, for correlation with others that will be taken in future years, when changes in the structure and positions relatively with the stars can be detected.

The photograph depicts the nebulosity as extending about seventy-seven minutes of arc in *south following* to *north preceding* direction, and about sixty-seven minutes from *north* to *south*, like a cloudy mass broken up into wisps, streamers, and curdling masses—densely dotted with stars all over its surface and over the regions surrounding—many dark areas with and without either stars or nebulosity in them. Other areas have both faint stars and faint nebulosity in them, and they are shown to the faintness of about eighteenth magnitude. Some remarkable black tortuous rifts meander through the nebulosity on the *north preceding* half of the nebula; their margins are sharp and well defined in the midst of dense nebulosity. They are as cleanly cut as we see the cañons of great rivers, but their width may in reality be millions of miles, for we have no reason to assume that the nebula is nearer to the earth than are the stars. It is indeed possible that the stars which dot the surface are nearer to us than the nebula.

Speculations as to the further development of this nebula (if it be one body and not several) cannot at present add to our existing knowledge, nor can we picture by the imagination what changes in its structure may be developed in, say, a million years; but we have no basis for expecting that more than microscopic changes can be detected in a human lifetime. Let us take these hints for what they are worth. Here is the record made available to all who may desire to exercise their imagination concerning this very large subject.

Letter.

[The Editors do not hold themselves responsible for the opinions or statements of correspondents.]

THE LEGEND OF LOUGH DEREVARAGH.

To the Editors of KNOWLEDGE.

SIRS,—Perhaps some of the fishermen who frequent Lough Derevaragh in West Meath, when the "green drake" is in season, may like to hear the strange old legend attached to its waters, as worded by Sir Henry Piers of Tristernaght, in 1682. "Lake Direvreagh, in the Irish language soundeth 'the lake of a severe or hard judgment,' thus called, I suppose, from the sad exclamation of a poor fellow, of whom the story goes that in a frosty season he attempted to drive a cow he had stolen across the lake, the ice being strong enough, and he in haste, he drove somewhat hard, and the cow chancing to stumble or slide, fell, and in the fall broke one of her legs. Hereupon, not knowing better how to dispose of her, he kills her in the place, and with the help of his companions carries off the hide and flesh. When safe and at rest he found he had forgotten his knife, immediately he returns to the place where the blood and entrails of the cow lay, which by this time had so far thawed the ice, that when he drew near the ice broke under his weight, and falling in, the ice closed again about his neck and cut off his head. The man falling made a hideous outcry—which was heard at a great distance—to this purpose, 'Oh! oh! I have received a sad or severe sentence or judgment.'" Sir Henry Piers also mentions that about Lough Iron and Lough Direvreagh may be found "a small fish without spot, of the shape almost of a herring, a fish very pleasant and delightful, but not taken in large quantities." He tells us it is only found in the month of May, and sparingly, and adds, that "the natives call it 'goaske.' I do not know how to English it."

How much of the "Legend of Derevaragh Lake" may be founded on fact is doubtful, but certainly the inhabitants of West Meath possess fertile imaginations and belief in old traditions, as the following "cures" for toothache, which are commonly practised, will show:—"A sufferer seeks for a human skull containing teeth, and pulls out one of these teeth by catching hold of it with his own." Should this operation be properly performed he will never again have toothache! Another superstition is that if a tree has been struck by lightning a piece of the charred wood carried about in the pocket will prevent toothache. But I might multiply such "cures," and will only ask the readers of KNOWLEDGE if the "delightful goaske" fish has ever been discovered in this century, and what it may be?

FRANCES I. BATTERSBY.

Science Notes.

Sir Norman Lockyer has lately been experimenting with flexible film, with the idea of adapting it to spectroscopic photography. The large concave Rowland grating which Sir Norman is now using has twenty thousand lines to the inch ruled on its surface, and is of twenty-one and a half feet radius, giving a spectrum thirty inches long. The focal field of this grating is considerably curved, and it is therefore impossible to get a sharp photograph of the whole spectrum on a glass plate—a difficulty which Sir Norman bridges by the use of a flexible film bent to the curvature of the field. The Kodak Company have sent us a magnificent print of one of the photographs thus taken, and it is without doubt the longest solar spectrum ever photographed at a single operation. It is thirty inches long, and shows the arc spectrum of iron, with a comparison spectrum of the sun from wave-length three thousand six hundred to five thousand two hundred. It is hoped by using these films instead of glass plates at the next solar eclipse a larger number of photographs may be taken than hitherto in any given period of time.

Arrangements are in progress by the British Astronomical Association for the organization of two expeditions to observe the total solar eclipse of May 28th, 1900—the one to Portugal, Spain, and Algiers, the other to the United States. Members and their friends who contemplate

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PHOTOGRAPH OF THE NEBULA N.G.C. 2237-9 MONOCEROTIS.

By ISAAC ROBERTS, D.Sc., F.R.S.

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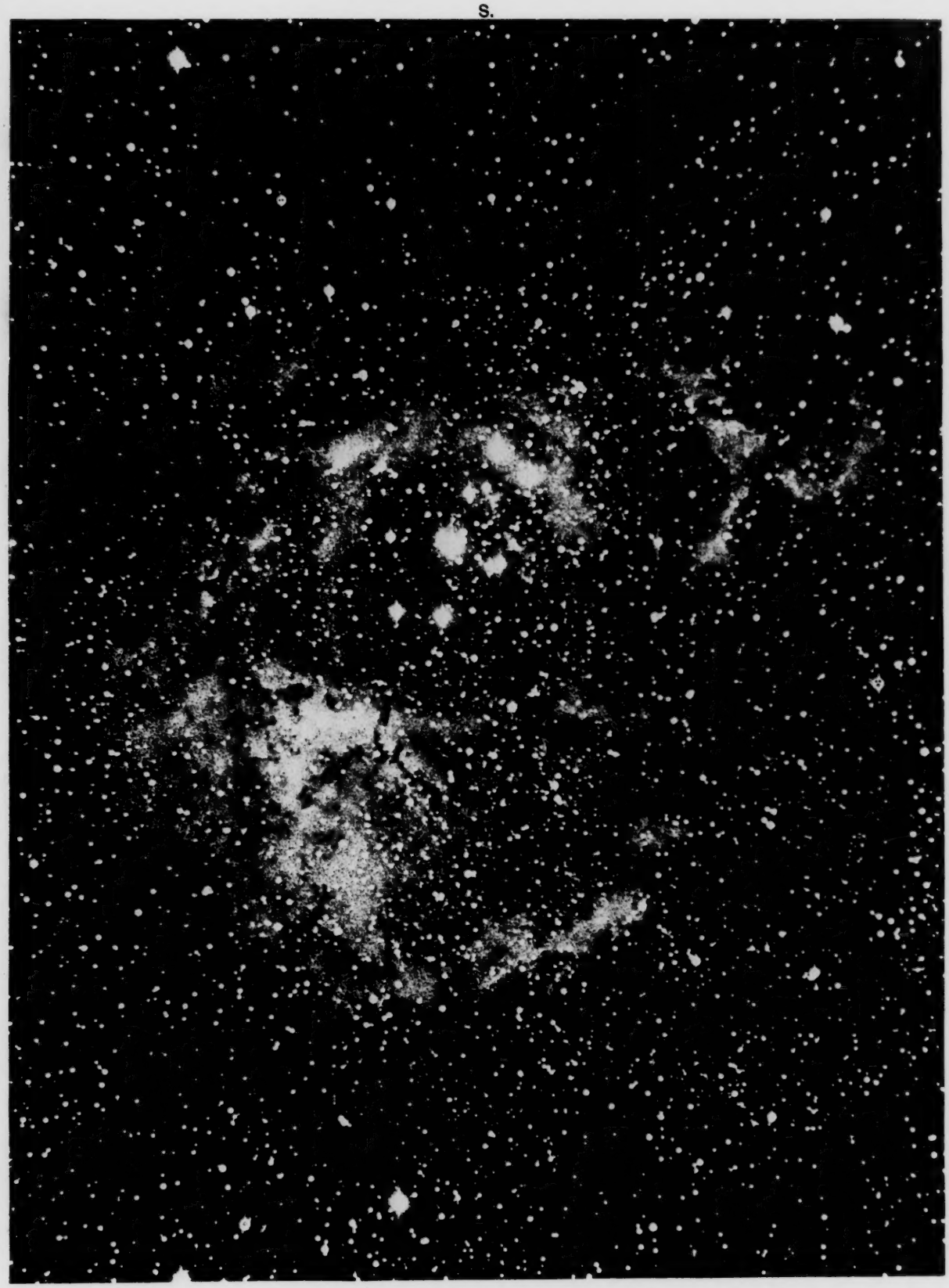

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taking part in one or other of these expeditions, should communicate at once with Mr. E. Walter Maunder, director of the European detatchment, or to the Rev. J. M. Bacon, who will have charge of the American party.

Dr. David Gill, her Majesty's distinguished astronomer at the Cape, has been awarded the fifth Watson medal by the American National Academy of Sciences. Rarely indeed has honour been more judiciously bestowed, for Dr. Gill's zeal, assiduity, and the trustworthiness of his work are recognised and appreciated by astronomers the world over.

The *fourth* Annual Congress of the South-Eastern Union of Scientific Societies will be held in the Sir J. Williamson's Mathematical School, Rochester, on May 25th, 26th, and 27th; president, Professor G. S. Boulger, F.L.S., F.G.S. Among many papers that will be read are: "Practical Hints on the Formation and Collection of Coleoptera," by J. J. Walker, R.N., F.L.S.; "The Sun and Eclipses thereof," with special reference to the total eclipse of May 28th, 1900, by G. F. Chambers, F.R.A.S.; and "How to Keep a Botanical Record," by Prof. G. S. Boulger, the president. Various excursions have been arranged, headed by specialists.

British Ornithological Notes.

Conducted by HARRY F. WITHERBY, F.Z.S., M.B.O.U.

SANDGROUSE IN LINCOLNSHIRE.—In the great invasion of Sandgrouse (*Syrrhaptes paradoxus*), in 1888, the first occurrence for Lincolnshire was recorded by me at the time (*Zool.* 88, p. 420), on May 18th, in a parish on the north wolds. There they appear to have continued for some weeks, and several were shot, one of which I got. It is a very remarkable fact that once again these erratic wanderers from Asian steppes have this year appeared, not only in the same parish, but the same field (twenty-five acres of sandy land, recently laid down to permanent pasture, as being too poor to cultivate). These Sandgrouse, about thirty, were first seen by the rabbiter in the last week of January, the same man whose son shot five in 1888; subsequently, by several competent observers in the neighbourhood, some of whom, by previous experience, had become well acquainted with the birds. The locality is lonely and retired, and it says much for those who from time to time saw them that they were never shot at or otherwise disturbed on this or on the adjoining farm. They did not always keep in one flock, but separated into parties, and frequently took a flight of about a mile to two large fields of wheat in the low country, and on being flushed, returned to the same field on the wold. In fact, this locality seems to have offered special attractions, and it was here I got the feathers from one of their dusting-places. During the arctic weather in March they became much tamer; the shepherd on the next farm told me he got so near them that he could see their "little woolly feet," —and he knew them well, having had one given him in 1888. He also said that they followed each other like partridges, but "wobbled" a good bit when running in the snow. They finally and altogether disappeared about March 23rd, at the break up of the storm. I have since been informed a supposed flight of Sandgrouse were seen on Flamborough Head in March.—JOHN CORDEAUX, Great Cotes House, R.S.O., Lincoln, May 13th, 1899.

THE ROOK AS AN EGG-STEALER.—The Mistle Thrushes, the operations of which I described in the March, 1898, number of KNOWLEDGE, have built in the same spot, within a few yards of my window, again this year. For the last week the birds have been sitting, and I have watched with much interest the sitting bird being fed by its mate. This morning, when both birds had left the nest for a few minutes, a Rook happened to settle in the tree. He immediately saw the nest and hopped on to a bough near it. Here he waited for a moment and looked all round him. Seeing nothing to be afraid of, I suppose, he hopped down to the nest, and taking out an egg jumped to another bough and swallowed the egg whole. After another careful look round, the Rook returned to the nest and made a dig into it with his beak, but in his hurry clumsily pulled out some of the lining of the nest instead of an egg. The accident apparently hid the eggs, because he now began to hastily pull the lining out and put it under his foot. From this an egg dropped to the ground. The Rook saw the egg drop, and instead of pulling out more lining, probed about with his beak and eventually found another egg, which was at once swallowed. Just then, both Mistle Thrushes returned, and seeing the Rook, raised their harsh war cry and flew at him furiously. But before they could reach him, the Rook had left the nest and retired to the thickest part of the tree. The Thrushes continued to swoop at him, and one of them flew so fiercely that it hit a bough and knocked a bunch of feathers out of its own breast. The Rook made no attempt to fight, but gradually edging to the outside of the tree suddenly darted into the open, pursued and tormented by the Mistle Thrushes until out of sight. Half-an-hour afterwards, the Mistle Thrushes were feeding peacefully upon the lawn, but their nest is deserted.—HARRY F. WITHERBY, March 25th, 1899.

ARRIVAL OF SWALLOW.—Last year I was able to report to you that I had seen my first Swallow on March 14th, which was the earliest of all in my records, this year I saw my first on March 29th. This is fairly early considering the bitter weather of a week since, when there were fifteen degrees of frost.—E. SILLENCE, Church Street, Romsey, 30th March, 1899.

MISTLE THRUSH SWALLOWING DROPPINGS OF YOUNG.—I am fortunate in being able to confirm Mr. Witherby's most interesting account of the extraordinary sanitation of the Mistle Thrush's nest, given in the March (1898) number, so far as a very brief observation goes. Yesterday (May 6th), the last young Mistle Thrush left a nest which is built in the fork of a beech tree five feet from the ground, and twelve paces from my study window; with a pair of field glasses I have an excellent view down into the nest. Unfortunately, I only discovered the nest one day before the last bird left, but what I saw corresponds exactly with Mr. Witherby's account. The parent bird came to the edge of the nest, fed the two young ones, waited a moment, then one of the two nestlings raised the hinder part of the body towards the parent who stood above it, and, leaning over it, when the dropping was extruded the parent bird seized it *in situ*, and promptly swallowed it; that the dropping was large may be inferred from the fact that the birds were just leaving the nest. The young birds were too well feathered to require covering for a quarter of an hour, as in Mr. Witherby's observation, and the parent bird flew away almost at once, but there was no possibility of mistaking that the fœx was really swallowed down, nor did I see any sign of disgorging. Whilst two birds were in the nest a dropping was swallowed at every visit; when only one was left I saw the parent bird leave the nest on two occasions without one, but that, of course, is easily accounted for. Every time I saw a dropping taken it was swallowed, not the largest even were taken in the beak only and dropped away from the nest.—ARTHUR EAST, Southleigh Vicarage, Witney, Oxon.

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Levantine Shearwater (*Puffinus yelkouanus*) *near Scarborough* (*Ibis*, April, 1899, p. 308). At the meeting of the British Ornithologists' Club, held on February 27th, 1899, Mr. Howard Saunders exhibited a male example of the Levantine Shearwater, shot by a wild fowler near Scarborough on February 5th. This is, we believe, but the third example of this Shearwater which has been recorded for the British Islands. The bird is an inhabitant of the Mediterranean and Black Seas.

Spotted Sandpiper (*Tringoides macularius*) *in Ireland* (*Ibis*, April, 1899, p. 314). There are many records of this American Sandpiper having visited our Islands, but few, if any, have been properly authenticated. Mr. F. Curtis exhibited, at the February meeting of the British Ornithologists' Club, a female specimen which had been shot on February 2nd, 1899, at Finea, Co. Longford, Ireland, by Mr. Frank Roberts.

Red Grouse and Bantam Fowl Hybrid (*Ibis*, April, 1899, p. 314). A remarkable hybrid between a male Red Grouse and a female Bantam Fowl was exhibited by Mr. J. G. Millais at the meeting of the British Ornithologists' Club on February 27th, 1899.

Cranes in Norfolk (*Zoologist*, March 15th, 1889, p. 119).—In his interesting "Ornithological Record from Norfolk," which Mr. J. H. Gurney annually contributes to the *Zoologist*, a record is given of four Cranes (*Grus communis*) having been seen by Mr. Pashley near the Gaven on April 7th, 1898. They were next reported as visiting a piece of water near the sea at Weybourne, and were subsequently seen at Runton, after which they took their departure, happily unmolested. Three hundred years ago the Crane used to breed in the fens of the east coasts, but now these birds pay us but the briefest and most occasional visits.

Lesser Whitethroat in the Outer Hebrides (*Annals of Scottish Natural History*, April, 1899, p. 109).—Mr. W. Eagle Clarke records that Mr. W. L. Macgillivray obtained a specimen of this bird on the west side of the remote Island of Barra, on October 24th, 1898. *Sylvia curruca* is a rare bird in Scotland, and has not hitherto, apparently, been obtained in the Outer Hebrides.

King Eider (*Somateria spectabilis*) *in the Shetland Islands* (*Annals of Scottish Natural History*, April, 1899, p. 111, and *The Field*, April 8th, 1899).—A male specimen of this beautiful and very rare visitor from the far north was obtained by Mr. Eustace Blankart, of Sandness, on the west side of Shetland, in Vaila Sound, on February 24th, 1899.

All contributions to the column, either in the way of notes or photographs, should be forwarded to HARRY F. WITHERBY, ***at 1, Eliot Place, Blackheath, Kent.***

Notices of Books.

The Life Story of Sir Charles Tilston Bright. By Edward and Charles Bright. 2 vols. (Constable.) Illustrated. £3 3s. net. Your mere reviewer of books stands appalled at this—it is at once so good and so bad! There is too much of it, and there is too little of it. Under no circumstances must it be lightly approached as a biography, for it is a vast deal more. While between its covers one finds the life-story of a man who was at once a genius and a "strong man," so also does one find a very complete history of the pioneer cables of the world. Nor is this all. Would you read technical detail of the manufacture, the laying, and the working of cables? Here you shall find it. Would you read of the customs of the Far East and the Far West? Then take this book. Are you interested in the flora and fauna by land and by sea? Again, this book. But, alas! the arrangement, or want of arrangement, throughout is bad, and one finds much needless repetition and very many stupid misprints. Yet through it all the strong personality of the man, his quaint humour, his calm patience, and his fierce determination are ever with us? To give one striking instance of each of these traits, Sir Charles was, upon one occasion, approached by an old schoolfellow of whom he had lost sight for a number of years, and on this unexpected meeting quite failed to recognise him. The latter recalled himself to Bright by remarking that they had been interrupted in a fight at school. And Sir Charles mildly suggested, "Let's finish it now." As to his patience, we may suggest his remark, "I don't say that we shall do it now, but we shall do it some time"—and this after more than one failure to lay the first Atlantic cable. And, as regards determination, what are we to say of the man who quietly suggested that he was in a position to "take" Arecibo if his operations there should be interfered with, or of the man who worked on while his staff were daily dying of fever—worked on, indeed, till he had actually to be carried aboard a ship bound for home, and even then left his work with great reluctance. It is interesting to note that this same energy of his led him into at least one curious little error. Quite early in the book we read of his having been bothered by a would-be inventor, who argued that the cable would not even sink to the bottom of the Atlantic, but must rather be held suspended at a certain depth by the great density of the water there. Sir Charles stated that this was absurd, since he had specimens of shells, etc., from the bottom of that same ocean. Now this was surely no argument to offer his opponent, since the latter, to be consistent, must surely urge that the *bottom itself was held in suspension*. Indeed, of the book in its entirety one hardly knows how to speak. It is certainly good enough to make us wish it were a vast deal better. The main fault probably lies in that we have some four books rolled into one, and of these four each *per se* would be good; but the tangle by no means brings out the merits of any one of them. The composite result is a record of very many useful and interesting facts, the collection of which must have entailed a vast deal of labour. Yet the interest and the use of the book are constantly tumbling one on top of the other, so that both are, to the reader who has not much time to spare, less easily accessible than they should be.

An Elementary Text Book of Botany. By Sydney H. Vines, M.A., D.SC., F.R.S. (Swan Sonnenschein.) 9s. The production of a satisfactory text book of botany becomes a more and more arduous task in proportion as the wealth of material increases, from which a selection has to be made. Prof. Vines dealt with this mass of detail in an admirable, if somewhat encyclopædic manner, in his well-known Students' Text Book. But experience has shown the necessity of further subdivision and the preparation of a book mainly addressed to beginners. The present volume occupies a position midway between the Student's Text Book and Prantl's Lehrbuch der Botanik, on which the former was founded. But Prof. Vines has not only reduced the bulk of his book; the contents have been revised, and many topics that are still under examination have been excluded. We think this principle of exclusion might have been carried still further. We are, however, grateful that the subject of nuclear subdivision is treated very shortly—centrospheres and centrosomes, whatever part they play, or are supposed to play in the process of nuclear division, do not appear in the text—but the omission of some other matters where our knowledge is not yet sufficiently precise might be recommended. For reasons of clearness and convenience the book is divided into four parts—Morphology, Anatomy and Histology, Physiology, and Classification, but the student is wisely advised not to read each part separately and consecutively, but to maintain a parallel study in each. In the last section we notice that though Algæ and Fungi are united in the one group Thallophyta; the Mosses and Ferns are not similarly connected under the common division of Archegoniatæ.

Kant on Education. Translated into English by Annette Churton. With an Introduction by Mrs. Rhys Davids. (Kegan Paul & Co.) 2s. 6d. This little book presents to English readers, for the first time, the admirable and suggestive "Thoughts on Education," which Kant prepared for his professorial courses, and which were originally published in Germany (*Immanuel Kant über Pädagogik*) nearly a hundred years ago. The book is furnished with an excellent introduction, in which Mrs. Rhys Davids traces the influence of Rousseau on the mind of the master, and bespeaks for his work the consideration of educators in our own day. "There is much in these lecture-notes worthy to be considered by educators for many a generation to come. Now and again the hand of the writer is on the pulse of the future. Always he is earnest, wise, and sane."

Volcanoes: Their Structure and Significance. By T. G. Bonney, D.SC., LL.D., F.R.S. (Murray.) 6s. The object of this work is well expressed in the title, and the result is to give us one of the most readable, and from the eminence of the author, one of the most instructive books on a series of phenomena whose complete explanation is not yet forthcoming. By picturesque and vivid language Prof. Bonney conducts his readers over historic and interesting ground where volcanoes have been and are in active operation. He calls up the picture that these volcanoes have presented when belching forth their

varied contents, by means of descriptions given by eye witnesses, and makes us realize the gigantic forces that must be at work to produce so magnificent a result. He takes us into the laboratory and examines and classifies for us the dust and fragments of the sedimentary or metamorphic or crystalline rocks that have been ejected from the open fissures. The stalactites of lava and the columnar or basaltic joining that are here and there met with are passed under review before the author conducts us into that instructive theatre of extinct volcanoes which the district of Auvergne has preserved for our study and delight. A chapter is given on the history of British volcanoes, the author drawing from and recognizing the admirable treasury of information compiled by Sir A. Geikie. It might seem that the number of facts collected and discussed would be sufficient to afford a complete theory of vulcanicity. Professor Bonney, however, regrets his inability to put forward any completely satisfactory hypothesis. Either some links in the chain of evidence still remain to be discovered, or the relations of those which we know have not yet been fully understood. We can affirm a fact more easily than we can offer an explanation. Admitting that a volcanic eruption is due to the upheaval of more or less explosive material at a high temperature, there still remains to be answered the apparently simple question—What causes the high temperature? Some may think that this question admits of an easy answer, but Prof. Bonney considers both the mechanical and the chemical theories that have been advanced, and finds both deficient.

Laboratory Manual on Astronomy. By Mary E. Byrd, B.A. 1899. (Ginn & Co., Boston, U.S.A.) The astronomy of to-day may be said to have specialized itself into two distinct forms. There is the astronomy of theory and of mathematics, and there is the practical astronomy of observation. Both are good in their kind; but it is to the former that the attention of our schools and colleges is almost exclusively directed, though it must be admitted that the latter is much more potent as a means of training and developing the intellect. It has always been assumed that large and complicated instruments are necessary for the practical working of astronomy, and, as a matter of fact, it is much less trouble to confine oneself to text-books. Miss Byrd's book, therefore, forms quite a new departure in astronomical manuals, and as a guide to the training of beginners in the actual, practical, out-of-door, study of the science, it deserves the highest praise. Apart from the intrinsic value of the manual, Miss Byrd's book will do good service if it persuades our teachers that the study of astronomy should begin with naked-eye observation, and that complicated and well-finished instruments are a hindrance rather than a help to the training of the beginner, where he or she could otherwise be induced to make the elemental instrument necessary to the observation. Though "no inroad has been made into the province of the regular text-book," there are two appendices which we would recommend to the study of observers. The first is by a leading authority—Prof. Arthur Searle—on "The Zodiacal Light," and the second on "Moonrise," by Prof. E. Frisby. We think that the students of Smith College are much to be congratulated in the possession of such an instructor and director of the observatory as we would judge Miss Byrd to be.

Photo-Micrography. By Edmund J. Spitta, L.R.C.P., M.R.C.S., F.R.A.S. (The Scientific Press.) 12s. This is one of the best books on photo-micrography that has yet come before our notice. Most of the volumes on the subject that have been issued of late years are little better than treatises on the technique of photographic processes, with an occasional chapter on photo-micrography culled from papers already published in the proceedings of the Microscopical and other societies. We are therefore glad to welcome a work like this, which devotes itself to its subject, and which is, at once, both original and practical. Every page offers evidence of extensive knowledge of minute detail and wide research, such as could only be shown by one who had a practical acquaintance with the difficulties that are to be met with in laboratory practice. The author treats of his subject under four heads, viz., illuminants, low power work, medium power work, and high power or critical work. The book, as a whole, is so good and so admirably arranged that one regrets to see that occasion is offered for criticism of any kind. The question of illuminants, which is treated of in Chapter I., does not, however, receive that attention that it merits. To dismiss so important a part of the subject with a brief dissertation of nine pages is, in our opinion, a defect which the author would do well to attend to in future editions. One result is that much has been omitted that might have been included with advantage. For example, magnesium ribbon, and the use of minute platinum wire loops with a Bunsen flame, rank among the best illuminants that the operator can use for low power and for medium power work. The author evidently has a *penchant* for lime-light, and, therefore, all other illuminants that do not, in his opinion, lend themselves for critical high power manipulations (a class of work which the majority of students have neither the means nor the opportunities of practising) are either accorded but scant attention or are ignored. Four chapters are devoted to the technique of low, medium, and high power work, and it is in these that Dr. Spitta best shows his grip of the subject. They teem with useful practical hints, and no one, whether a beginner or an advanced worker, can peruse these chapters without adding considerably to his knowledge. We have our doubts whether the author does not lay too much stress on the necessity of working only with the best, and therefore the most expensive apparatus. One of the greatest deterrents to the popularizing of photo-micrography among students has been the idea that good work can be done only with apparatus possessing the most expensive refinements in the way of mechanical adjustments to stages, condensers, lamps and objectives. For the few who do critical, high power work, these are essential, but not so for the majority for whom this book is intended, and who seldom soar above good medium power work. The two chapters on the microscope lenses, eye-pieces, and condensers are not, however, without considerable value, and, like the rest of this admirable work, they will well repay a careful perusal. The book is admirably printed and is profusely illustrated with sixty-three text illustrations and forty-one exquisite half-tone reproductions of the author's own photo-micrographs.

The Sound of a Voice that is Still. By Archie Campbell. (George Redway.) 5s. Accepting the good faith of the writer of this book, which his preface forbids us to doubt, we could wish that the voice in question had remained still until its owner had been able to make himself more familiar with his subject, or to adduce some new fact or fresh incident in his relations with the unseen universe. As it is, the book is of the earth earthy, the manner is almost brutal in its matter-of-fact directness, and its characters are of the most commonplace order. The introduction into such a circle of some spirits of the great departed is altogether too thin, and can only make the reader very tired of the Laird of Auchenoullen.

Journal of the Society of Comparative Legislation. Edited for the Society by John Macdonell and Edward Manson. (John Murray.) 5s. This is the first part of a new series, and contains a number of valuable articles, together with a review of the legislation of the Empire for 1897, with an introduction by Sir Courtenay Ilbert. A very useful article is contributed by Mr. Edward Manson, the Secretary of the Society, on "The Status of English Trading Companies Abroad."

BOOKS RECEIVED.

Annual Report of the Board of Regents—Smithsonian Institution, to July, 1897.

Gilbert White's The Natural History of Selborne. Parts I., II., III., and IV. Edited by Grant Allen. (John Lane.) Illustrated.

Technical Education Returns (England, Wales and Ireland), 29th July, 1898. (Eyre & Spottiswoode.) 1s. 3d.

Thornton-Pickard Album of Prize Pictures. (Dawbarn & Ward.)

Phenomena of Nature as seen from the Workshop and the Field. Part II. By James Walker. (Sonnenschein.) 2s. 6d.

A Manual of Library Cataloguing. By J. Henry Quinn. (Library Supply Co.) 5s. net.

The Naval Pioneers of Australia. By Louis Becke and Walter Jeffery. (Murray.) Illustrated. 7s. 6d.

The Hygiene of the Mouth. By R. Denison Pedley. (J. P. Segg & Co.) Illustrated. 2s. 6d.

Current Papers, No. 3. By H. C. Russell, F.R.S. With plates. (Read before the Royal Society of New South Wales.)

Applied Geology. Part II. By J. V. Elsden, B.Sc. (Quarry Publishing Co.) Illustrated.

The International Directory of Booksellers and Bibliophile's Manual, 1899. (Aldine Press: Rochdale.) 6s.

Energy and Heat. By John Roger. (Spon.) Illustrated. 2s.

Telephones: their Construction and Fitting. Fifth Edition. By F. C. Allsop. (Spon.) Illustrated. 3s. 6d.

The Entropy Diagram. By J. Boulvin. (Spon.) 5s.

XUM

Text-book of Practical Solid Geometry. By E. H. de V. Atkinson. (Spon.) 7s. 6d.

Under the Searchlight. By Agnes Weston. (Royal Sailors' Rest, Portsmouth.)

Catalogue Général des Livres de Sciences. (J. B. Baillière et Fils, Paris.)

Scientia: Exposé et développement des questions scientifiques à l'ordre du jour. (Georges Carré and C. Naud, Editeurs, Paris.)

A Message to Garcia. By Elbert Hubbard. (George H. Daniels, New York.)

Sewage-Analysis. By J. Alfred Wanklyn and William John Cooper. (Kegan Paul & Co.) 5s.

Man: Past and Present. By A. H. Keane. (C. J. Clay & Sons.) 12s.

Old Clocks and Watches and their Makers. By F. J. Britten. (B. T. Batsford.)

Obituary.

On April 20th, at his studio near Primrose Hill, at the ripe age of seventy-nine, died Joseph Wolf—animal painter. A painter who produced the most beautiful and life-like pictures of animals and birds that have ever been seen, who was characterized by Landseer himself as "without exception the best all-round animal painter that ever lived," Wolf was, nevertheless, quite unknown to the public, and little known to picture lovers. Born on 21st of January, 1820, in the little village of Möerz, near Coblenz, the son of a farmer, Wolf showed at a very early age an extraordinary love for Nature, and that faculty for close observation which enabled him in after years to make live for ever on paper or canvas the animals and birds he loved. His first artistic efforts were paper silhouettes cut out with a pair of scissors. But he soon took to a pencil and a brush, and notwithstanding the greatest possible discouragements from his parents, by the light of his own genius, and the force of his own character, he taught himself to draw, and eventually, at the age of sixteen, won his father's consent to be apprenticed to a lithographer at Coblenz. Three years of the dull routine of a lithographic draughtsman's office, which would destroy all originality in most, left him uninjured—indeed this training in exactness and minutiæ stood him in good stead in after life. After a year at home, he journeyed to Frankfort and Darmstadt with some miniatures of birds and beasts. These were shown to the zoologists, Dr. Küppell and Dr. Kaup, who recognised his extraordinary talent and first introduced him to the world as an animal artist. From that time onwards Wolf's career was assured. For eight years or so he worked extremely hard on the Continent, illustrating many scientific works, as well as going through the drudgery of an art school. At the age of twenty-eight Wolf came to London, where his first commission was to complete the illustrations for Mr. G. R. Gray's standard book on the "Genera of Birds." It is of course impossible to enumerate here a tithe of the enormous number of works—scientific and popular—which were illustrated or partly illustrated by Wolf. Amongst the chief we may mention the "Proceedings" and the "Transactions" of the Zoological Society of London, the "Ibis," Andersson's "Lake N'Gami" (1856), James' "Æsop's Fables" (1858), Wood's "Illustrated Natural History" (1859), "Zoological Sketches by Joseph Wolf" (1861 and 1887), Stevenson's "Birds of Norfolk" (1866), Elliot's Monographs (1872—1873—1883), Gould's "Birds of Great Britain" (1873), and "Birds of Asia" (1883), Dresser's "Birds of Europe" (1879), Brehm's "Thierleben" (1876), "Big Game Shooting," Badminton Library (1895). Those who knew Wolf deplore his loss, not only as a consummate artist and accomplished naturalist, but as a kind and generous friend, unmercenary, a man of noble character, a hater of all that is false and a lover of all that is true. We would refer those who wish for a full account of Wolf's life and work to Mr. A. H. Palmer's "Life of Joseph Wolf," published in 1895 by Messrs. Longmans.

WIRELESS TELEGRAPHY.

A MODEST genius, James Bowman Lindsay, who lacked the art of self-advertisement, first discovered wireless telegraphy, and fully appreciated the possibilities of the invention, but he was unable to secure sufficient public attention to carry his idea into the domain of practical utility. He conceived the project in 1831, nearly three-quarters of a century ago, and in 1857 he transmitted messages across the Earl Grey Dock without the aid of wires; while, later on, he made calculations tending to show that by selecting two stations in Britain—one in Scotland and one in Cornwall—and two corresponding stations in America, it would be possible to send messages across the ocean without the intervention of a cable. According to Tesla, a German electrician, some years ago, also sent messages over a space of about thirty-six miles without the use of wires. Moreover, a passage in the *Spectator* (No. 241, 1711) has an interesting bearing on this subject; it reads thus:—"Strada, in one of his prolusions, gives an account of a chimerical correspondence between two friends by the help of a certain loadstone, which had such virtue in it that if it touched two several needles, when one of the needles so touched began to move, the other, though at never so great a distance, moved at the same time and in the same manner. . . . . By this means they talked together across a whole continent, and conveyed their thoughts to one another in an instant over cities or mountains, seas or deserts."

To Hertz belongs the distinction of having discovered the electric waves, and by his experiments he proved that electricity in its progress through space follows the laws of optics, but, so far, no one has obtained such practical results with these Hertzian waves at anything approaching the distance as Signor Marconi. Fog, or even the most solid substance, has no effect on the waves; they can penetrate walls or rocks without being materially affected, but in the case of large metallic bodies intercepting the path of the rays there remains some slight difficulty to overcome. These ether waves, as Prof. Fleming calls them, travel through space with the velocity of light, about one hundred and eighty-six thousand miles a second, and when they impinge on the receiving apparatus at a distant station they excite a sympathetic current, something after the fashion of a violin or piano, the strings of which respond to sounds of the same wave-length. As to how far Signor Marconi's system is an invention and how much a development, the words of Mr. W. H. Preece are to the point. He says: "Mr. Marconi has invented a new relay, which, for sensitiveness and delicacy, exceeds all known electrical apparatus . . . he has not invented any new rays, his transmitter is comparatively old, his receiver is based on Branly's coherer. Columbus did not invent the egg, but he showed how to make it stand on its end, and Marconi has produced from known means a new electric eye more delicate than any known electrical instrument, and a new system of telegraphy that will reach places hitherto inaccessible." Indeed, many workers have devoted their time and skill in the laboratory to the perfecting of the details, so to speak, of the new scientific machine which Signor Marconi has forged from their materials as a new weapon competent to in some measure annihilate time and distance, which form such formidable barriers to the world's progress. A vast gulf separates laboratory experiments from practical large scale demon-

strations conducted with all that regularity and freedom from failure which constitute the imperative condition in order to be of public utility.

In 1866, Mr. S. A. Varley discovered that certain metals in powder cohere together when electrified wires act upon them, a subject which was further developed by Mr. E. Branly in 1890. Marconi produces his ether waves by electric sparks passing between four brass balls, a device of Prof. Righi, following up the classic researches of Heinrich Hertz. A thin layer of nickel and silver dust, mixed with a trace of mercury, is placed between two knobs or electrodes fused into a glass tube. Ether waves from a distant station cause this metallic dust to cohere and so convert it into a conductor of the electric current, which is conveyed to a Morse receiver, and so marks the signals in ink on a travelling slip of paper. A hammer, worked by an electro-magnet, is arranged so as to tap the tube in order to shake loose the metallic dust and so break the current between each stroke of the recording pen. Metal conductors are so disposed in the instrument as to admit of adjustment in order that only ether waves of a certain kind may pass through. By this means a single transmitter can work a number of receivers, provided they are tuned by adjusting the conductor, as a tuning-fork resounds to a certain note.

For communicating over thirty, or even a hundred miles, the entire outfit does not exceed more than one hundred pounds in all, and, apart from the high flagstaff, the whole apparatus can be arranged on a small kitchen table.

Marconi's new instrument can be fixed upon a vessel and influenced from a transmitting station on shore. A ship fitted with a receiver may have an electric bell inside it, which can be revolved so that only when pointing in the direction of the transmitting station will the ether waves operate on the bell. Thus, a ship in a fog will be able to ascertain its bearings as accurately as with the compass. For war purposes, the apparatus can be installed snugly in the middle of the ship, out of reach of the enemy, and, unlike flags, semaphores, or lamps, unseen by the foe. It has been shown that, by means of parabolic reflectors, the rays can be projected in any desired direction, and received by a similar reflector, a feat which has been accomplished by Marconi up to a distance of some two and a half miles; although the instrument fails to act if it is more than a certain distance to the right or left of the centre line of the beam, this part of the problem presents a promising field for further investigation.

Already successful installations of wireless telegraphy have been worked between Alum Bay and Bournemouth, fourteen miles; Poole and Bournemouth, eighteen miles; signals have been regularly exchanged, and the experience of fourteen months has proved that no kind of weather in England could stop the working of the apparatus. Last autumn an installation between the Royal Yacht "Osborne," and Osborne House, during the Prince of Wales' illness, showed that as the yacht moved about in various portions of the waters round the Isle of Wight, there need be no doubt as to the possibility of telegraphing across long stretches of land. The system has been in operation since December between the South Foreland and the East Goodwin Lightship, a distance of twelve miles, and during the past month France and England have been successfully connected. The English station is at the South Foreland Lighthouse, near Dover, and that of the French at Wimereux, near Boulogne; messages were passed backwards and forwards with the greatest ease, and the experiments open up boundless possibilities for the application of wireless telegraphy in the everyday business of life.

It is to the employment of the vertical conductor that Marconi attributes his success. A length of 150 feet of copper wire is run up a flagstaff to draw its message out of space, and print down in dot and dash on the paper tape the intelligence ferried across thirty miles of water by the mysterious ether. Up to certain limits the distance to which signals can be sent varies as the square of the height of the flagstaff. A wire, twenty feet high, carries a signal one mile; forty feet high, four miles; eighty feet, sixteen miles; one-hundred and sixty feet, sixty-four miles; and so on. The speed at which messages can be sent is equal to that of the cable, from twelve to eighteen words a minute. A remarkable circumstance is that simply by the appearance of the dots and dashes recorded on the tape, Marconi can tell which of the three operators at Boulogne is transmitting a message, brought about by a difference in the touch. "There is a distinctive handwriting about it."

Sanguine as some are for the future of Marconi's system, many eminent scientific men see nothing in it; indeed, the new acquisition is passing through the usual ordeal which all great innovations have to endure. About seventy millions of telegraphic messages are sent annually in this country, while telephonic messages have reached not less than four-hundred and fifty millions, but no one believed such a result would ensue when the telephone system was launched. Whatever may be the future of the system, the late demonstrations inspire much hope for the speedy development of another great scheme of international communication.

J. M.

THE KARKINOKOSM, OR WORLD OF CRUSTACEA.—IX.

By the Rev. Thomas R. R. Stebbing, M.A., F.R.S., F.L.S., F.Z.S., *Author of "A History of Crustacea," "The Naturalist of Cumbrae," "Report on the Amphipoda collected by H.M.S. 'Challenger,'" etc.*

LA DIGNITÉ DU CHEZ-SOI.

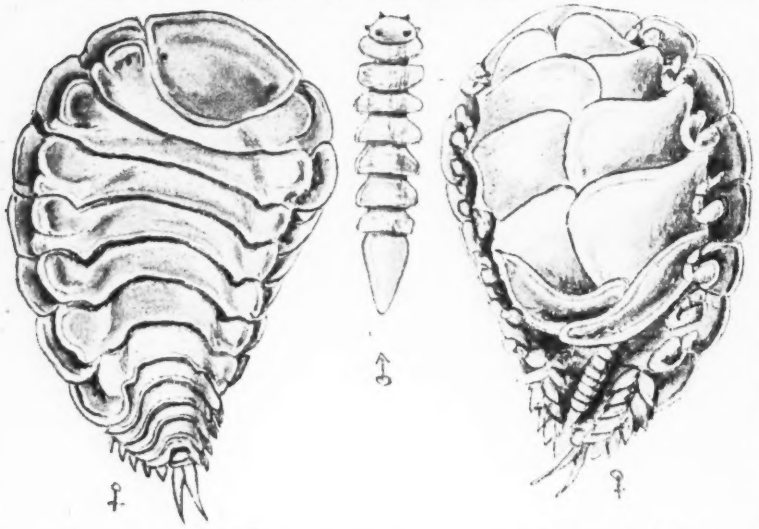
THE ancient Egyptians were a wise and understanding people. But the system they adopted of mummifying themselves and their cats only showed an amiable weakness. It was a vain attempt at thwarting that law of existence which calls upon every conscientious vegetable and animal to live and let live, or, in other words, to eat and be eaten. Like all other creatures, the crustaceans are anxious to prolong to the utmost limits the first part of this alternative. Hence, though they don't care for embalming, they have been driven to evolve or invent resources of shelter and seclusion, that might otherwise seem unnecessary for beings free to range or to repose in the soft and roomy bosom of the ocean.

Houses and clothes are not, like food, an original necessity of animal life. They are an acquired taste, the beginnings of luxury and civilization. Probably they were adopted by man in the guise of fortress and armour before they became the costly ministers of his comfort and vanity. But, however the desire for a domicile may have arisen among ourselves, the construction and use of a homestead are no exclusive triumphs of human intelligence, although the fettering of freedom thereby entailed, the rates and taxes, the overcrowding and the drainage, may be all our own.

It must not be expected that marine invertebrates will show any great advances in architectural skill. Of crustaceans it may be said, that, whatever else their dwellings are designed for, they are never designed for display. But, simple as each dwelling viewed by itself may be, when

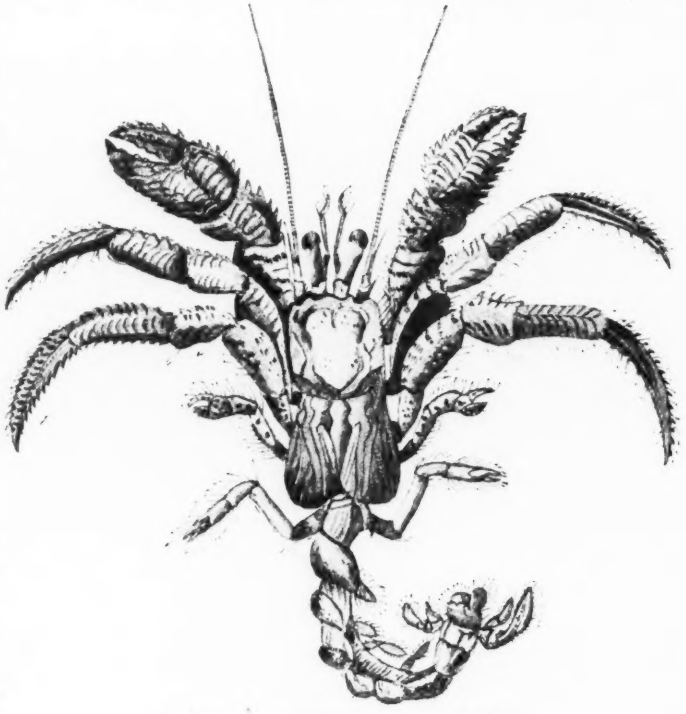
considered in the mass these habitations show no inconsiderable variety of structure and material and position.

In the history of evolution a very odd question arises in regard to this matter. At the first thought it might seem childish to ask whether the crustacean made the dwelling or the dwelling made the crustacean. But there are instances in which we know for certain that the occupant did not make its house, and yet is so curiously adapted to it that we may speak without extravagance of the house having made its occupant. By making is not intended original creation, but that modifying which gives the creature its place in classification. Take, for example, the isopod *Bopyrus*, of which the female brings into the world her numerous offspring while ensconced on one side of a prawn beneath the carapace. Or study, in Sars' "Crustacea of Norway," the *Pleurocrypta marginata*, a similar animal similarly situated in a *Galathea*. Notice in either case the rows of little dumpy ineffective legs. Notice what an awkward, one-sided twist the body has. Yet many of their relatives have legs large and long, and capable of making good play; many of their relatives are perfectly symmetrical, and so are their own small insignificant husbands. But the mothers, in that lying-in home which they have borrowed from prawn or *Galathea*, close to the branchial chamber of the host, where the supply of wholesome water for their young is always turned on, are no longer in need of wandering feet. As for their figure, since they cannot make the lodging exactly fit it, they let their figure be canted to fit the lodging.



Pleurocrypta marginata Sars. Female in Dorsal and Ventral View; Male on Breathing-plates of Female; and also detached.

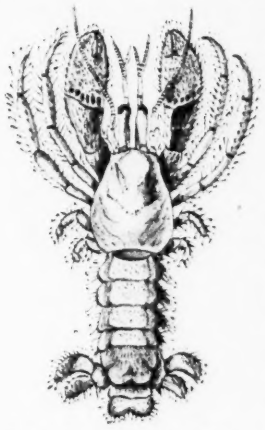
Still more striking examples are afforded by the hermit crabs. The name, *Pagúrus*, under which Fabricius grouped them rather more than a century ago, is a Greek word which has been variously explained and variously applied; but, if we take it to mean, as it very well may, the Fixing Tail, it will be found highly appropriate to the characteristic members of this group. Everyone knows the general appearance of one of these hermits, a sort of cross between a deformed crayfish and a periwinkle. Its usual abode is the shell of some univalve mollusc. This it occupies either as an abandoned tenement, free to the first comer, or by picking out the original occupant, or else by right of conquest over some other hermit. At the approach of danger or inquisitorial notice, a suspiciousness, bred perhaps of its own want of scruple, bids the hermit retire quite out of sight into the recesses of the shell. At other times it freely protrudes its front, with the stalked eyes and antennæ, the large claws, and the tips of the two long pairs of walking legs. Often, as in so many other crustaceans, the claws are unequal, some species being commonly, so to speak, left-handed and others right-handed. The business of the larger claw is not only to repel the foe and seize the prey, but also to bar the entrance, the massive hand and finger themselves forming a tightly fitting and efficient door, and sometimes a very handsome one. In *Pagurus granulatus*, the great West Indian hermit, the granulation to which the specific name is due gives the large claws an appearance of being closely studded with jewels. The next two pairs of legs, which are long and slender, enable these animals to walk with agility, with their houses on their backs, not only under water, where the weight would be less appreciable, but in the open air on the sea-shore, and in the case of some species to great heights and distances inland. In



Pagúrus arrosor (Herbst). From Savigny.

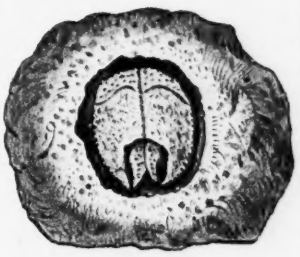
ordinary crabs the two remaining pairs of trunk legs take their share in the walking, running or swimming movements for which many crabs are exceptionally well endowed. But in the hermits the two pairs in question are so abruptly shorter than their predecessors, and are so placed that they cannot co-operate in this way. Their services to the organism, however, are none the smaller for their stunted growth. As Dr. C. W. S. Aurivillius has shown, their size, their armature, the plane of motion of their joints, are all convenient adaptations. They are bound to be short and specially folded to suit the conditions of their house-room. The strange-looking pads upon them, when pressed against the smooth sides of the house, supply a fulcrum to enable the animal to draw in and out the heavy claws and trunk. The masses of hairs serve to transfer a glandular secretion from little pits in the carapace to plaster the walls of the dwelling.

Next we come to the tail part, or pleon. From one point of view this flabby corkscrew of a tail, as seen in common hermits, is very unsatisfactory. It is shockingly unsymmetrical, with some of its appendages entirely wanting on one side. Though belonging to a crustacean, it is to a great extent not crustaceous. This is very unlike a proper crab, the tail of which is practically nothing but crust, and it is equally unlike the tail of a lobster, in which solid meaty muscle is enclosed in a firm, neatly-jointed covering. But it is evident that the hermit, after thinking out the idea of annexing the shell ready-made by a univalve, found it a great convenience to grow a soft and curly tail part, while symmetrical pairs of pleopods or swimming-feet were no longer indispensable when it had given up the practice of swimming. Only in the apex of the tail, that part which in crawfishes and prawns and the like forms the powerful terminal "fan," the hermit had good reason for preserving, not indeed symmetry, but strength of integument. If anything ever was evolved or designed for a special object, one would say that the caudal fan of the Macrura was designed or evolved to facilitate the motion of the animals possessing it. The hermit crab, by twisting it into the recesses of a univalve shell, has twisted it into an instrument for resisting motion. By means of this so tightly does it cling to its adopted home, that it repels any invitation to leave it as stoutly as Charles the First's little son repelled the hypothetical proffer of a crown, and translates into action the child's emphatic language, "I will be torn in pieces first."

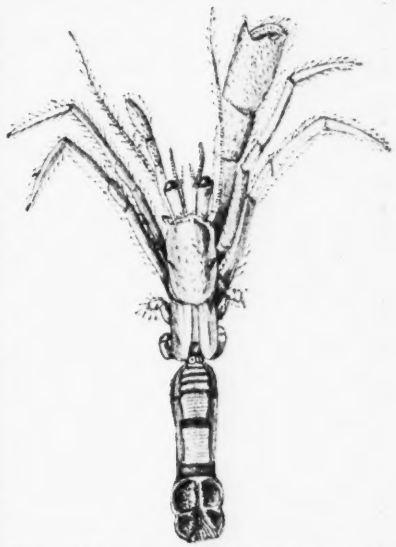


Pylochéles Agassizii A. Milne-Edwards.

What now will happen if the obliging mollusc should not be at hand to accommodate the hermit? It is not a simple answer that can be given to this question. As Mr. Edward Step has lately observed, a homeless hermit may shelter itself in a niche of a rock. As Aurivillius has shown, various zoophytes come to the assistance of the crustacean, on what may be called reciprocal terms, though we are not just now concerned with the bargain. Most persons know the inconvenience of accommodating an increasing family in a house not made of india-rubber or other elastic substance. They will understand, then, the position of a hermit-crab which goes on growing, whereas its home, the shell of an absentee mollusc, has lost the power of growth. Where shells are plentiful, a change may easily be made from a small one to a larger. But in some districts such changes become difficult or impossible. Then it is that the living and growing zoophyte, over-spreading the shell, enlarges the borders of it for the benefit of the crustacean tenant. Again, several members of the Paguridean tribe are exempt from any bigoted devotion to conchology. There is the species *Pylochéles Agassizii*, which ensconces itself in the hollow of a stone, or of a hard silicious sponge, and, as no twisting of the tail is required for such a residence, the sensible little animal preserves its symmetry. So, too, in the tail-part does *Xylopagûrus rectus*, which lives in a piece of reed or of hollow wood, and of which a peculiar habit has been noted or inferred. Pagurids in general, almost of necessity, enter their house tail foremost. But the *Xylopagûrus* is widest at the tail-end, and has been found neatly fitted into a domicile in which the back entrance is wider than the front. As, therefore, the tail could not have passed the front doorway, it is reasonable to conclude that the head was introduced at the postern. Some Pagurids neither appropriate shells nor any other ready-made houses. Among these is the head of the tribe, the great *Birgus latro*, symmetrical in shape, terrestrial in habit, fat, and well-flavoured. It is surnamed the Robber, not because it is any more a robber than the rest of us, but because it happens to have come into rivalry with man, the universal robber, in an acquired taste for cocoanuts. These it eats, using also the fibres of the husk to line its deep burrow in the ground. Its tree-climbing powers have been disputed; but on this point we now have Mr. J. Stanley Gardiner's authoritative statement, quoted in Mr. L. A. Borradaile's recent paper (*Proc. Zool. Soc. Lond.*, June 7, 1898): "The robber-crab is very commonly found in the tops, both of Pandanus and of cocoanut trees, from which latter I have had it thrown down to me by the natives. It is stated by them to break off the nuts, and often to fall with them, never killing itself, as the cocoanut is underneath. I have seen them constantly clinging to the fruit of the Pandanus,



The same in a hollow stone, closing the entrance with its claws. From Huët and Bouvier.

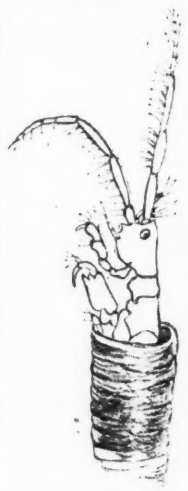


Xylopagûrus rectus A. Milne-Edwards. From Huët and Bouvier.

the fallen segments of which, after they have been chewed by the crab, cover the ground." Mr. C. Hedley (in Whitelegge's "Crustacea of Funafuti," Sydney, 1897) observes that as "the cocoanut is foreign to the native flora, and of comparatively recent introduction from abroad, it follows that the taste for this nut has been acquired in historical times by *Birgus*, whose original food was probably Pandanus fruit." Major Alcock ("A Summary of the Deep-Sea Work of the *Investigator*, 1899") recalls to mind Sir Francis Drake's report of certain desirable oriental crabs that "for want of other refuge, when we came to take them, did climb up into trees to hide themselves, whither we were enforced to climb after them." For additional proof that this was no mere traveller's tale, Mr. C. W. Andrews, in his recent visit to Christmas Island, brought the camera to bear on the question, and photographed a crab in a tree-top, and a crab in the act of climbing a tree.

Mr. Gardiner, again quoted by Mr. Borradaile, gives the following interesting account of the domesticity of a species in a quite different group of crustaceans. The *Lysiosquilla maculata* (Fabr.) is found, he says, in the boat channel at Rotuma. "It lives in pairs in tunnels on the sandy bottom. These are sometimes as much as twenty feet long, and usually have two exit holes. Each hole is inhabited by a male and a female, which take up their positions at the two exits, with the *dactylus* and *propodite* of the raptorial claw widely extended, and just projecting. Any small fish passing over is seized, and the animal retreats with it into its tunnel." Such then is a hunting lodge, as employed by some of the rapacious and strongly armoured Squillidæ. Similar tunnels are used, no doubt for similar freebooting purposes, by various more or less prawn-like animals, such as *Upogebia* and *Callianassa*, of which specimens are occasionally found on our own coasts. The *Callianassa* has an additional reason for hiding in a sub-aquatic tunnel, in that it is a very soft-bodied animal. It is of singular appearance because of the size and strength exhibited by the terminal joints of a single claw. A strange crustacean, nearly allied to the two genera just mentioned, is the *Thalassina anómalus*, and Dr. J. Anderson gives a strange account of its dwelling-place. The notice occurs in his description of the reptiles of the Mergui Archipelago (*Jour. Linn. Soc. Lond.*, Vol. XXI., p. 344, 1889). Where a lizard was common in a swamp, at the mouth of a small freshwater stream, there, among the palms, the crustacean "had thrown up the great mud mounds that occur over its underground chambers. They were strewn with the fallen leaves of the palm, and were more or less riddled with holes made by the crustacean, the eminences being converted into islets at high tide."

On the river-crabs that by the winding streamlet, beneath the roots of large umbrageous trees, construct their burrows, and that sit at the entrances with one eye on the romantic scenery around them and the other on any suspicious-looking tourist passing by, there is not time to dilate as they deserve. A cursory hint must suffice for the *Dromia*, which, with singular coolness and inflexible tenacity, embeds itself in a colony of compound ascidians, and for the miscellaneous crustaceans which in early life find their way into the glassy network of a Venus's Flower Basket, destined, it would seem, to live and die in that graceful enclosure. The crowd of crabs and shrimps and cumaceans and isopods and amphipods which simply bury themselves for protection in the sand from time to time at any convenient spot, can scarcely be said to have homes. In their case the facility of change, the absence of all local obligation or of any need to think about repairs, must destroy the very idea of a house. But this happy-go-lucky freedom from care is not shared by all even of the small crustacea. Those which, like the isopod known as the Gribble, and the amphipod called *Chelura terebrans*, bore into submerged timber, have indeed, a sort of home, though they are continually changing it; but the change is made by almost imperceptible degrees and on very easy terms, since it appears that they only leave one chamber because they are eating their way into the next. Some amphipods, however, construct tubes, either free or attached, by help of a glandular secretion, which issues through a tiny aperture in some of their toes. This becomes a firm cement, and the structure is often consolidated still further by interwoven bits of seaweed, fragments of shell, grains of sand, and other contributories. Pity would be wasted on the cramped area of the lodging, since it is always ample for the lodger. An instance of this is afforded by Mr. Robert Templeton's account of a little tubicolous amphipod which he picked up "at Mauritius, or on the way thither," between sixty and seventy years ago. "While watching it," he says, "which I did for some hours, I was exceedingly surprised and amused to find it disappearing from one end of the tube, and reappearing like magic at the other, having doubled itself up towards its belly in the passage, but with such quickness, considering the narrow calibre of its mansion, that I could hardly credit my eyes but that it had two heads, and, indeed, a gentleman who was with me in the pavilion at the time could not be persuaded to the contrary. The animal, however, scarcely remained a second at this extremity, but shot back to the one it had formerly occupied; and during the time I watched it I never saw it remain permanently at it, or rather, I should say, for a longer period than a second, or a second and a half at furthest." So independent is real energy of the narrowness of the sphere in which it works.



Cerapus abditus Templeton, emerging from its tube. From Templeton.

Microscopy.

By John H. Cooke, F.L.S., F.G.S.

In biological laboratories, where the microtome is in constant use, it is of importance that the edges of the microtome knives should be kept in as perfect a condition as possible. To prevent dulling of the edge, which results from oxidation, the knives should be kept immersed in a one per cent. solution of carbonate of sodium. This treatment will not only prevent them rusting, but will also render them perfectly asceptic.

Dr. Buchner's recent discovery that the alcoholic fermentation set up by the yeast plant, is due to the chemical power of an amyloyte acting in a manner similar to digestive ferment, caused a sensation among those who had hitherto held that the action of yeast could not be dissociated from the living plant. To demonstrate the action of this ferment, the yeast cells should be thoroughly disrupted by grinding them up with quartz sand, and, subsequently, submitted to a pressure of about five hundred atmospheres. Some few cells may escape destruction in this process, and these should be searched for with the microscope, and either disrupted or removed. The resultant powdered mass will act similarly to untreated yeast, thus showing that the fermentative action hitherto attributed to the living cell is, in reality, due to a fermentative enzyme.

The nucleus of the malarial parasite has been demonstrated by Ziemann with the aid of a new stain, consisting of a mixture

of a one per cent. watery solution of rectified methylene-blue and a one per cent. watery solution of eosin.

At a recent meeting of the Royal Microscopical Society of London, Mr. E. M. Nelson exhibited a new objective by Zeiss, called a "plankton-searcher," a low-power water immersion objective, designed for use in examining living objects in water.

Vegetable fibres may be distinguished from animal fibres by treatment with iodine and dilute sulphuric acid. The former take a characteristic colour, either yellow or blue, while the latter do not. The re-agents should be prepared as follows:—Dissolve one part of potassium iodide in one hundred parts of distilled water, and add an excess of pure iodine, so that the solution shall always remain saturated. Mix one part of distilled water with three parts of sulphuric acid, and, when cool, add two parts of Price's glycerine. Both re-agents should be kept in glass-stoppered bottles, and as they are liable to change they should be occasionally tested on known fibres.

These re-agents, applied under the microscope, afford a means of determining the species from which the fibre is derived. To do this, some cells should be separated, extended on a glass slip, and slightly moistened with glycerine. The length and breadth may then be determined with a micrometer, and note should be made, at this stage, of the shape and degree of taper of the cells. Allow a small drop of iodine to flow under the cover, removing any surplus with blotting paper. As soon as the iodine has penetrated, apply the sulphuric acid in the same way, carefully watch the results, and compare them with the action of the re-agents on known fibres.

A cheap and effective section-lifter may be made by hammering out flat the end of a copper wire of one-eighth inch in diameter and four inches long. The hammering should be done on a smooth iron, and when it is of the requisite width it may be trimmed with a pair of scissors and smoothed on a whetstone.

The current issue of the *Proceedings of the Royal Society of London* contains a suggestive article by Miss Catherine Raisin "On certain structures formed in the drying of a fluid with particles in suspension," in which are described the many interesting forms that the powders of various rocks exhibit when mounted in water and dried. These forms are classified, the conditions and causes of their formation are discussed, and suggestions are made as to the possible explanation they afford of the origin of many of the structural characters of rocks in Nature.

Excellent finishing varnishes may be made by well mixing on glass artists' oil paint with gold size. Only sufficient for immediate needs should be mixed at one time. Sealing wax, dissolved in alcohol, is also useful, but only the best wax should be used, otherwise the varnish is liable to chip and leave the glass.

Dr. G. H. Bryan suggests, in the pages of the *Journal of Applied Microscopy*, the following ingenious device for the more effective preparation of desmids, diatoms, and other minute mounting material. The removal of all traces of acid necessitates frequent washings and decantations of the residues. It is, therefore, important that the vessel in which these operations are performed should hang vertically, otherwise much of the residue rests against the sides of the vessel and gets carried away during the decantation. Dr. Bryan gets over this difficulty by suspending the test-tube by a U-shaped piece of wire across the base of which an india-rubber ring is fixed. The test-tube is placed in the ring, the elasticity of which allows the tube to hang perfectly freely. The precipitation of the diatoms is hastened if the tube be set swinging slightly. This device will also be found useful for washing and collecting the insoluble residues of limestones and other rocks.

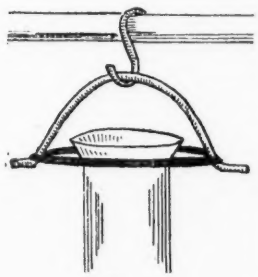


Fig. 1.

Cross-sections of fibres may be obtained by glueing together a mass of the fibre, bedding in paraffin, or by rolling them like a cigarette in a piece of sheet wax. When cut, the mass of mixed sections is placed in benzole or alcohol, when the wax soon floats on top and may be poured off.

The following method of mounting in balsam on the cover, and backing up with black varnish, will be found useful for such objects as foraminifera, minerals, seeds, etc. Cement a thin glass cover to a slip by applying a little balsam to the edge of the cover, and accurately centre it on the turntable. Place and arrange the objects on a thin coating of balsam in the centre of the cover. When dry and set the objects may be completely covered with balsam and put into the dry oven until hardened. If the objects are white a layer of Brunswick black is now laid all over the balsam; if the objects are black white zinc cement should be used. In either case care should be taken to lay them on in thin coats, and allowed to dry in the open air before the next layer is applied. Now remove the glass cover from the slip by slightly heating it. It may now be turned over and mounted on the cell designed for it. Gelatine dissolved in water, with enough alcohol added to liquefy it from the jelly state, is a good preparation for fastening the cover to the cell.

NOTES ON COMETS AND METEORS.

By W. F. DENNING, F.R.A.S.

SWIFT'S COMET (1899A).—During May this object proved an extremely interesting one, and was faintly visible to the naked eye. It will continue favourably visible in June, though with rapidly declining brightness. The comet will be situated in the head of Draco on June 1st, and it may be seen about 1° south of the fourth magnitude star ξ Draconis. On June 8th the comet will pass over the star ν Herculus (magnitude 4·7), according to the ephemeris by Moller in *Ast. Nach.*, 3556, of which the following is an abbreviation:—

Date. 1899.	R.A. h. m. s.	Dec.	Distance in Millions of Miles.	Brightness.
June 2	17 36 8	+ 55° 14′	53	1·34
„ 6	16 24 46	+ 49° 35′	57	1·03
„ 10	15 39 2	+ 43° 2′	63	0·75
„ 14	15 9 57	+ 36° 59′	71	0·53
„ 18	14 50 51	+ 31° 49′	80	0·38

Moonlight will then interfere, and at the end of June, when our satellite will have left the evening sky, the comet will have practically travelled beyond the reach of ordinary telescopes.

TEMPEL'S COMET (1873 II).—The return of this comet is now expected under favourable circumstances, and the following ephemeris has been published by M. Schulhof, *Ast. Nach.*, 3554:—

Date. 1899.	R.A. h. m. s.	Dec.	Distance in Millions of Miles.	Brightness.
June 5	19 40 19	− 4° 5′	55	1·27
„ 9	19 46 12	− 4° 25′	52	1·44
„ 13	19 51 57	− 4° 54′	50	1·63
„ 17	19 57 35	− 5° 33′	47	1·83
„ 25	20 8 31	− 7° 23′	43	2·28

The comet moves slowly eastwards in Antinous.

TUTTLE'S COMET cannot be seen to advantage, as its position will be near to, and south of the sun.

HOLMES'S COMET is shortly expected, and Zwiers gives a sweeping ephemeris in *Ast. Nach.*, 3553. The brightness of the comet is steadily increasing. Its position at the end of June is close to λ Arietis, forming a triangle with α and β Arietis, but it will become more favourably placed at a later period of the summer. At the opposition of this comet in 1892, about six hundred observations were made, and the orbit has been determined with considerable accuracy. Prof. Barnard, of the Yerkes Observatory, does not, however, regard the reappearance of the comet as at all certain. He says: "The failure to see the comet previous to its sudden apparition on November 6th, 1892, near the Andromeda Nebula, its uncometary appearance, its peculiar freaks, and final, utter disappearance from the heavens, connected with the nebulous appendage shown on the photograph of November 10th, would strongly suggest that the object was not a comet at all, but more probably a result of some celestial accident. I think there is no question but this comet will never be seen again, and doubtless before now it has ceased to exist as an individual body" (*Monthly Notices*, 1899, March, p. 357).

XUM

THE LEONID METEORIC SHOWER.—In an interesting and valuable paper (*Ast. Nach.*, 3555), Drs. Stoney and Downing give the results of some calculations of the "Perturbations of the Leonids," made by various members of the computing staff at the *Nautical Almanac* office. They find that the earth will encounter the main stream (*i.e.*, the region through which the earth passed in 1866, November 13th) on 1899, November 15th, 18th, or just before sunrise on November 16th next. This conclusion is, however, based on two assumptions, and the authors point out that the predicted time of maximum, as above stated, "can only be offered with reservation."

In the *Astrophysical Journal*, March 1899, Prof. Barnard gives the details of his observations of the Leonid meteors in 1898. On November 9th, at 10h. 50m., he saw a magnificent golden fireball, four or five times brighter than Venus, shooting from near α Cassiopeiæ to the stars in the head of Draco. This meteor was probably a Cetid with radiant at about 45°+6°. On November 14th, Prof. Barnard found the radiant point of the Leonids at 149°+24° from the recorded paths of thirteen meteors. On November 15th the great Yerkes telescope was turned towards the radiant, and two new nebulæ were discovered. Prof. Barnard expresses the opinion that though the moon will be present at the Leonid epoch next November, her light will not materially interfere with photographic observations of the meteors in cases where the exposures are not too prolonged.

APRIL METEORS (LYRIDS).—Observations of this shower were comparatively meagre this year owing to moonlight and partially overcast skies. Prof. A. S. Herschel, at Slough, watched the heavens on April 16th, 17th, and 19th, but noticed little indication of the radiants in Virgo, Scorpio, Aquila, etc., which usually furnish many of the meteors seen at this period. A shower in Canes Venatici appeared, however, to be in active evidence. On April 4th, 11h. 51m., he saw a meteor as bright as Sirius, with path from 215°+64° to 188°+41°, which it pursued slowly. On April 19th the Rev. T. E. R. Phillips, of Yeovil, saw a fine meteor, two or three times as bright as Jupiter, descending from 209°+5° to 190°−26°. The colour of the meteor was pale green; it was four seconds in traversing its path. This object, like that seen by Prof. Herschel on April 4th, accords with a radiant in Cepheus at 315°+60°. On April 30th, 9h. 55m., Mr. Taylor, of Henley-on-Thames, observed a meteor as bright as Arcturus, passing from κ Serpentis to midway between ϵ and ζ Herculis. On May 3rd, 12h. 5m., Prof. Herschel recorded a second magnitude meteor travelling from 191°+16½° to 167°+42°. It was orange yellow, length of path 32°, and duration of flight three and a half seconds. The two latter meteors appear to have been directed from a well-known April shower of Virginids at 208°−10°.

In June no very special showers are observable, and meteors are often scarce in the strong twilight prevailing at this season. Fireballs are sometimes casually noticed, and they appear to have belonged to a southerly radiant in Scorpio.

THE FACE OF THE SKY FOR JUNE.

By A. FOWLER, F.R.A.S.

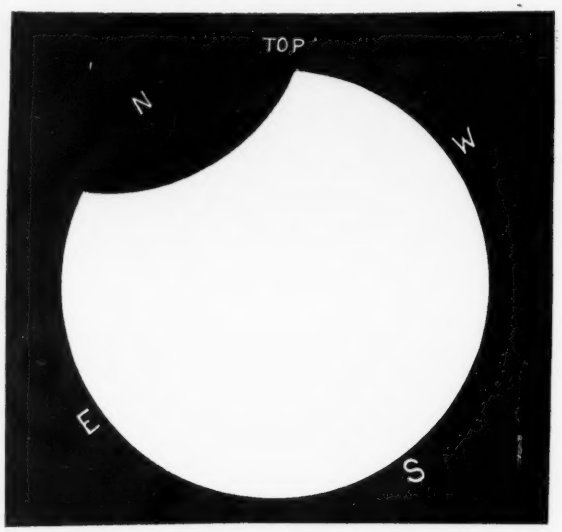
THE SUN.—On the **1st** the Sun rises at 3.50, and sets at 8.6; on the **30th** he rises at 3.48, and sets at 8.18. He enters Cancer, and summer commences at 4 P.M. on the **21st.**

There will be a partial eclipse of the Sun on the morning of the 8th, which will be visible throughout the British Islands and northern Europe. The following table, giving local particulars, has been drawn up from the data given in the *Nautical Almanac*.

Locality.	Magnitude.	Begins.	Greatest Phase.	Ends.	Angle from North Point.		Angle from Vertex.	
					First Contact	Last Contact	First Contact	Last Contact
		A.M.	A.M.	A.M.				
Greenwich ..	0·188	4.43	5.17	5.53	42° W.	29° E.	6° W.	70° E.
Cambridge ..	0·197	4.43	5.19	5.56	43° W.	30° E.	7° W.	71° E.
Oxford	0·200	4.43	5.18	5.55	43° W.	31° E.	7° W.	71° E.
Liverpool	0·233	4.44	5.22	6.1	46° W.	34° E.	12° W.	73° E.
Edinburgh ..	0·263	4.46	5.26	6.8	49° W.	37° E.	16° W.	73° E.
Dublin	0·253	4.19	4.57	5.38	48° W.	36° E.	15° W.	74° E.

The magnitudes are expressed as fractions of the Sun's diameter; the times are all Greenwich mean times with the exception of those for Dublin, which are Dublin mean times. All position angles are for direct image.

The accompanying diagram illustrates the amount of the eclipse for Greenwich and the immediate neighbourhood, and shows the position of the eclipsed part with respect to the horizon.



THE MOON.—The Moon will be new on the **8th**, at 6.21 A.M.; enter her first quarter on the **16th**, at 9.47 A.M.; will be full on the **23rd**, at 2.20 P.M.; and will enter her last quarter on the **30th** at 4.45 A.M.

On the **28th**, there will be an occultation of κ Piscium, magnitude 5·0. Disappearance at 11.22 P.M., at 32° from north point (70° from vertex); reappearance at 0.10, 278° from north point (315° from vertex).

On the **23rd** there will be a total eclipse of the Moon, invisible at Greenwich, but visible in India, China, Australia, New Zealand, and the Pacific Ocean.

THE PLANETS.—Mercury is not favourably placed for observation this month. He is a morning star until the **14th**, when he is in superior conjunction with the Sun.

Venus also is a morning star, but is too near the Sun for easy observation with the naked eye. Her distance from the earth is increasing, and the apparent diameter is only 11″.

Mars may still be seen in the evening, but he will not be very conspicuous, and only those observers who have large telescopes can hope to make out any of his markings. At the beginning of the month he lies a little to the north-west of Regulus, and afterwards describes a path towards β Virginis. It will be interesting to note his proximity to Regulus on the **11th**, **12th**, and **13th**. He sets shortly after midnight at the beginning of the month, and about 11 P.M. at the end.

Jupiter will be seen in the evening in Virgo. His path is a slow and short westward one until the **28th**, when the planet is stationary. The polar diameter diminishes from 39·6″ to 36·8″. On the **1st** he will be due south at 9.18 P.M., setting about 2.30 A.M.; and on the **30th** he will set about half an hour after midnight. The satellite phenomena are most interesting on the evenings of the **6th**, **7th**, **14th**, **15th**, **22nd**, **25th**, **29th**, and **30th**.

Saturn will be in opposition on the **11th**, so that the

present month is very favourable for observations of this planet. The planet, however, is nearly 22° south of the equator, and he will, therefore, have a low altitude even when on the meridian. He describes a westerly path, lying about 3° north of θ Ophiuchi. On the **4th** the polar diameter of the planet will be 17″, the outer major axis of the outer ring 42·6″, the outer minor axis of the outer ring 19·1″, the inner major axis of the inner ring 27·1″, and the inner minor axis of the inner ring 12·2″. The rings are widely open, and their northern surfaces are visible.

Uranus may be observed throughout the evening, but he is very low in the heavens. He may be found almost midway between ν Scorpii and ρ Ophiuchi. The meridian passage is about 11.30 P.M. at the beginning of the month, and 9.36 P.M. at the end. The apparent diameter is 3·6″.

Neptune is not observable. He is in conjunction on the **15th**.

THE STARS.—About 10 P.M. at the middle of the month, Cygnus will be in the east; a little south of east, at a considerable altitude, will be found Lyra; while in the same direction, but a little lower, Aquila will be seen. Near the meridian will be Hercules, Corona Borealis, α Ophiuchi, Libra, and Scorpio. Arcturus will be a little west of the meridian, Virgo rather low in the south-west, and Leo almost due west.

Chess Column.

By C. D. LOCOCK, B.A.

Communications for this column should be addressed to C. D. Locock, Netherfield, Camberley, and posted on or before the 10th of each month.

Solutions of May Problems.

No. 1.

(By H. Bristow.)

1. Q to K7, and mates next move.

No. 2.

(By T. Hane.)

Key-move—1. Q to Kt2.

If 1 . . . K to K6, 2. R to R4, etc.
1 . . . K to K4, 2. Q to Bsq, etc.
1 . . . K to B4, 2. K to Q4, etc.

CORRECT SOLUTIONS of both problems received from E. Servante, Alpha, John Baddeley, H. Le Jeune, A. H. Doubleday, G. J. Newbegin.

Of No. 1 only, from Miss Theakston, W. de P. Crousaz, Percival K. Hogg, W. Clugston, G. G. Beazley, W. J. Bearne.

Of No. 2 only, from Capt. Forde, G. C. (Teddington).

Two or three correspondents are thanked for pointing out that No. 1 in the April number is by W. Finlayson.

W. S. Branch.—Many thanks for the information, problems (which appear below), and copy of the *Cheltenham Examiner*.

Capt. Aguilar.—There are no practical jokes in KNOWLEDGE. The main variation of No. 2 (April) is 1. B to R8, K × R; 2. K to Kt7, K moves; 3. K. mates. There is no stalemate.

Capt. Forde.—The defence to 1. B to QB2 is K to Q4; a near "try." You appear to have mastered the greater part of No. 2.

D. R. Fotheringham.—There is a defence to 1. B to Kt6, provided by 1. . . B to Ktsq.

Miss Theakston.—After 1. K to Q4, K to Kt6 (best); 2. R. to Kt6ch, K to B7 (best), and there is no mate. It is an excellent try, probably foreseen by the composer.

G. C. (Teddington).—If 1. B to QB2, K to Q4.

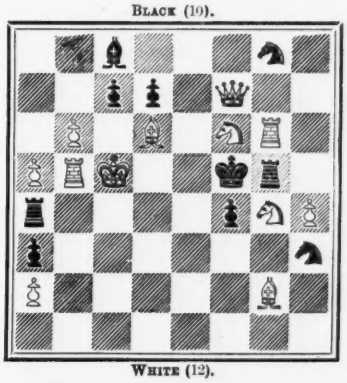
E. Servante.—Congratulations on your very successful first attempts. Your solutions were the first to arrive.

PROBLEMS.

By W. S. Branch (Cheltenham).

No. 1.

BLACK (10).

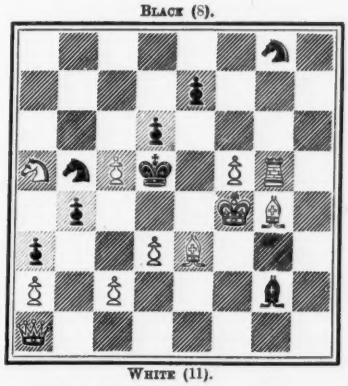


WHITE (12).

White mates in two moves.

No. 2.

BLACK (8).



WHITE (11).

White mates in two moves.

CHESS INTELLIGENCE.

Mr. Showalter won his return match against M. Janowski by 4½ games to 2½. He had previously defeated the same opponent in a "series" of six games by 4 to 2, and has evidently greatly improved since his severe defeat in the first encounter.

On April 21st and 22nd, a match between Oxford and Cambridge combined against the combined Universities of America was played by Atlantic cable. The English team won by 3½ games to 2½. The score was as follows:—

BRITISH UNIVERSITIES.		AMERICAN UNIVERSITIES.	
C. E. C. Tattersall (Camb.)	½	K. G. Falk (Columbia)	½
A. H. W. George (Ox.)	0	A. S. Meyer (Columbia)	1
L. McLean (Camb.)	1	C. S. C. Avensberg (Harvard)	0
A. P. Lacy-Hulbert (Ox.)	0	L. A. Cook (Yale)	1
G. E. H. Ellis (Ox.)	1	W. W. Young (Princeton)	0
H. G. Softlaw (Camb.)	1	W. Cutchings (Harvard)	0
	3½		2½

The following game was played in the Anglo-American cable match last March :—

"Ruy Lopez."

WHITE. (C. D. Locock.)	BLACK. (S. P. Johnston.)
1. P to K4	1. P to K4
2. KKt to B3	2. QKt to B3
3. B to Kt5	3. Kt to B3
4. Castles	4. Kt × P
5. P to Q4	5. Kt to Q3
6. B × Kt	6. KtP × B (*a*)
7. P × P	7. Kt to Kt2
8. Kt to Q4 (*b*)	8. Kt to B4 (*c*)
9. Kt to Q2 (*d*)	9. B to K2
10. P to QKt4	10. Kt to K3
11. Kt × Kt	11. QP × Kt (*e*)
12. Q to Kt4	12. Castles
13. Kt to K4	13. K to Rsq
14. R to Qsq	14. Q to Ksq
15. R to Q3	15. P to KB4
16. P × P en pass	16. P × P
17. Kt to Kt3 (*f*)	17. P to KB4 ?
18. B to Kt2ch	18. B to B3
19. B × Bch	19. R × B
20. Q to R4 !	20. R to Bsq
21. QR to Qsq (*g*)	21. Q to Kt3
22. R to Q8 (*h*)	22. B to Kt2
23. R × Rch	23. R × R
24. Q to Q4ch	24. K to Ktsq (*i*)
25. Q × P (*j*)	25. P to B5 (*k*)
26. Q × B (*l*)	26. P × Kt (*m*)
27. Q × P (B6)	27. Q to R4 (*n*)
28. R to Q2 (*o*)	28. Q × Pch
29. K to Bsq	29. Q to R8ch
30. K to K2	30. P × P
31. Q × Pch	31. K to Rsq

Drawn Game.

NOTES.

(*a*) Possibly to avoid a similar position to that which occurred on two other boards in this match. Another reason may be found in the next note.

(*b*) Steinitz gives 8. B to Kt5, B to K2; 9. B × B, Q × B; 10. R to Ksq, and erroneously concludes in favour of White. Black has merely to Castle, followed by Q to K3, with a perfectly safe game.

(*c*) Very risky would be the attempt to win a Pawn by 8. . . P to QB4, 9. Kt to B5, P to Q3; 10. Q to B3, P × P; 11. RQsq, Q to B3; 12. B to Kt5. Nor can he move the KB, on account of Q to Kt4.

(*d*) With a view to Kt to Kt3; but he decides afterwards on attacking the Knight in a bolder manner.

(*e*) Forced, if he wishes to Castle; for if he take with the BP, White checks first, and then plays the Queen to KB3.

(*f*) Probably best, if only to make room for the Queen at K4 in case Black plays P to K4. Black's reply looks like a blunder; his best move was 17. . . P to QR4 probably.

(*g*) 21. Kt × P can be played, but is not so strong as the move made, which avoids all complications. White is correct in thinking that the quickest way of winning is by obtaining a passed Pawn on the Queen's side.

(*h*) For similar reasons, White rejected here 22. Kt to R5, P to K4; 23. R to KKt3, Q to R3, etc.

(*i*) Best. Q or R to B3 would lose the exchange.

(*j*) The Pawn will keep. 25. P to KB4 first prevents any reaction, and would secure an easy victory.

(*k*) The best chance; for if 25. . . B to Bsq, then 26. P to KB4, as before.

(*l*) Too risky. He should play the Knight to Bsq.

(*m*) After 26. . . Q × P; 27. R to KBsq, P × Kt, it would be very difficult for White to win. For this reason White decides to run a great risk at his next move.

(*n*) Very ingenious, though it happens to be unsound.

(*o*) Intent now on saving what looked like a lost game, White finds the only move to draw. But he could have obtained a very lucky win by 28. Q × Pch, K to Rsq; 29. R to Q8 !, Q × Pch; 30. K to Bsq, Q to R8ch; 31. K to K2, Q to R4ch; 32. P to B3, Q to QKt4ch; 33. P to B4, Q × QKtP; 34. Q to B6ch, etc., exchanging all the pieces and winning with the QRP or KBP.

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